June 13, 1911.

POWER

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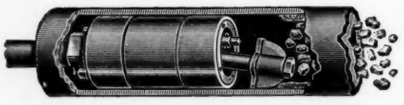
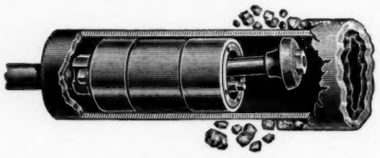


The Dean removing scale from the tube of a water tube boiler.



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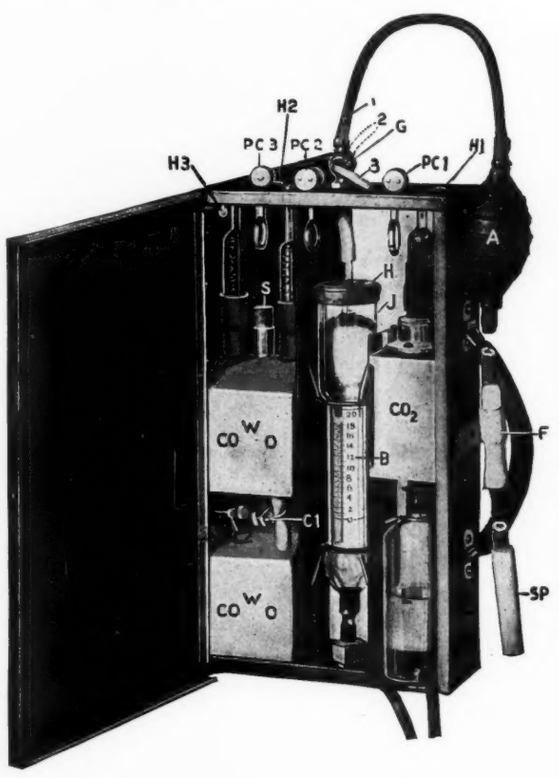


POWER

Vol. 33 NEW YORK, JUNE 13, 1911 No. 24

JUST what does and what does not constitute success is a question that has taxed the minds of men of many ages and if the various definitions which have been given had only been compiled it would have made a most interesting volume.

A few years ago a famous platform orator defined success as, "Finding your place and filling it," and this would appear to be all sufficient.

The speaker in illustrating his definition said that the question of money, while believed by the average layman to constitute the measure of success, was absolutely immaterial and that a crossing watchman doing his duty in such a manner as to leave nothing more desired, was more of a success than the man, who, through greed, selfishness or mere chance, accumulates several million dollars in a comparatively short time.

Now, to apply this to the engineer,—is the man who is chief engineer of a large central station of large manufacturing establishment, more of a success than the plain engineer of a small but flourishing factory, in a quiet portion of the city, who feels that the small position is the limit of his capabilities and operates it accordingly, leaving nothing undone that could be done to better the operating conditions?

He is not. He may be making more money, but he is not keeping his plant any nearer, or perhaps as near, the goal of perfection, measured by the limitations of the plant, as the man in the smaller position.

Most men lack one or more of the necessary requisites to success. Some men have all the necessary skill and knowledge, but lack the power of stick-to-it-iveness; others may lack that rare gift of handling subordinates; others may have the last two and not know just what to do when they get the crew together.

Neither is success measured by a diploma from some technical or other school, or an engineer's license with a gold seal, conspicuously displayed, or by a vast library of books pertaining to the profession, or even by all the various rules and formulas in common practice, memorized. All these things, while very desirable, are not absolutely essential to success.

A certain engineer on the railroad quite frequently called upon the fireman to "keep 'er hot 'n' wet," and almost had to have the fireman call out the names of the stations as they arrived. He always had the fireman read the train orders to him, and was known to report "flews lakin" and "new diver braike chu" on his return from a trip, yet when he coupled on to the limited, he would get it over the road on schedule time if the train held together, and on the least amount of fuel possible. Out of some 250 engineers on the road, he was never below the first half dozen in the monthly "performance sheet." That man found his place and could fill it; he was a success.

And it is just so in stationary practice. How many of the older generation, now operating engineers, the "Dad Eldridge" class, are there who received a college or technical education? Very few. Many there are who did not get even a fair country school education. But they had those necessary native qualifications that go to make a man a success; grit, ambition and a determination to win, and, last but not least, horse sense.

To be a success, it is thus clear that it is not necessary to be chief of a 100,000-horsepower plant. The thing to do is to find your notch, stick to it, work, be on the job and leave nothing to be desired in economy of operation and general appearance of the plant.

Horsepower of a Fan Blower

By Albert E. Guy

The results of some tests showing the influence which the form of the vanes has upon the horsepower and the head produced. Formulas are given showing the approximate velocity of flow and horsepower developed.

A problem frequently met with is that of finding the horsepower of a fan blower when the diameter of the rotor, width of vanes at the tip, etc., are known. This typical problem may be solved only when the necessary data embodied in the "etc." are known; otherwise it may be readily shown that two fans, having the same inlet and outlet diameters, the same width of blades, revolving at the same rate of speed and delivering the same volume of free air per unit of time, may produce widely differing pressures. Thus, with the lower pressure, the air horsepower would be almost negligible, while with the higher pressure, which might be an extreme for the class of fan considered, the air horsepower, and consequently the shaft horsepower, would be matters of prime importance. This discrepancy is due simply to the fact that in either case the vanes, although of the same width, must be designed to suit the required conditions of pressure.

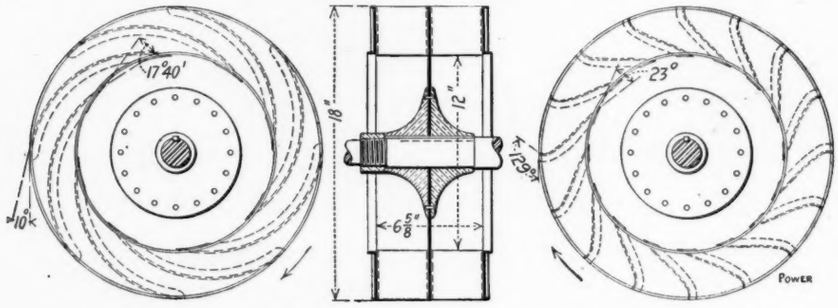


FIG. 1. IMPELLERS USED SHOWING CURVATURE OF VANES

About two years ago the writer, to show the direct applicability of centrifugal-pump formulas to the design of fan blowers and to prove that a complete line of standard apparatus could be designed without making preliminary and special experiments for obtaining so called coefficients of correction, chose two extreme sets of conditions and designed special apparatus to meet them.

It was proposed in one case to furnish 7000 cubic feet of free air per minute at a static pressure of 22 inches of water, and in the other, 5250 cubic feet of air per minute at a pressure of 5 inches of water, the speed being 3600 revolutions per minute in both instances. A spiral form of casing was designed, and an impeller fitted into it, each set of conditions being met by a special impeller; but to add to the difficulties and to render the proofs more conclusive, the inlet and outlet diameters, and the width of the vanes, were kept the same for the two impellers. Fig. 1 shows the principal dimensions and forms of the impellers.

When completed, the apparatus was connected directly to a steam turbine and the high-pressure impeller driven at the specified speed. To determine the capacity of the fan and to obtain the curve showing the relation of volume to head, the speed was kept constant while the volume delivered was progressively increased by changing the nozzle areas at the end of the discharge pipe. The head was recorded simultaneously with the volume to which it corresponded. Various speeds above and below that specified were tried in the same way, the results being shown by the series of curves given in Fig. 2.

The steam and exhaust pressures at the turbine were recorded for each point of the curve, not for the purpose of ascertaining the steam consumption, but in order that later on, the blower being disconnected and replaced by a prony brake, the same steam and exhaust conditions could be reproduced at the proper speed and the corresponding brake horsepower recorded. With the latter data the efficiency of the apparatus was obtained and is represented by curves covering the useful range of the impeller.

The low-pressure impeller was tried next, but on account of the small amount of power required to drive it and the unsuitability of the turbine for the purpose of measuring that power, it was not possible to ascertain the efficiency with sufficient accuracy to permit representation by curves, as was done with the first impeller. However, it was observed that for the point aimed at in the design, the efficiency was not less than 60 per cent.

The curves *A* to *H* in Fig. 2 are for the high-pressure impeller and curves *K*, *L*, *M* are for the low-pressure impeller. It is apparent that neither impeller was suitable for the requirements of ordinary work. The usual requirements are that a practically constant head be maintained for a wide range of volume variation. In the present case such a condition could have been met only by varying the speed, and the turbine was not well adapted for such a speed variation.

However, a comparison of the capacities of these two fans is interesting. At 3600 revolutions per minute 7000 cubic feet of free air were delivered against a head of 21.8 inches of water by the high-pressure fan, while the same quantity was delivered against a head of 1.6 inches of water by the low-pressure fan. The air horsepowers were nearly pro-

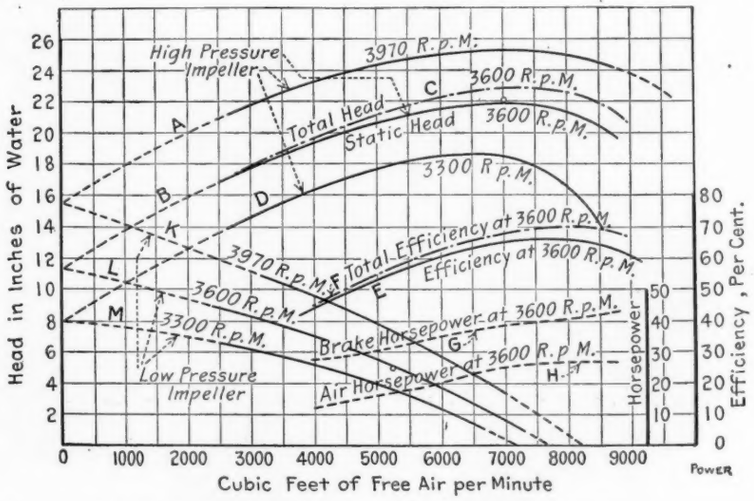


FIG. 2. CHARACTERISTICS OF THE TWO IMPELLERS TESTED

portional to the heads, or in the ratio of 13.6 to 1. At the same speed and for a volume of 5250 cubic feet of free air per minute, the brake-horsepower ratio would be about 4.5 to 1.

The impellers illustrated by Fig. 1 are not recommended for practical work. The speed of 3600 revolutions per minute is too low for the high-pressure impeller, or, the latter's diameter is too small for the speed. Moreover, the reversed form of vane is not desirable, as it entails a great frictional loss, and while it is theoretically correct for turbine work, it is not so for pumping purposes. The speed of 3600 revolutions per minute is far too high for the low-pressure impeller; the vanes are consequently too long and entail a frictional loss out of proportion to the head worked against.

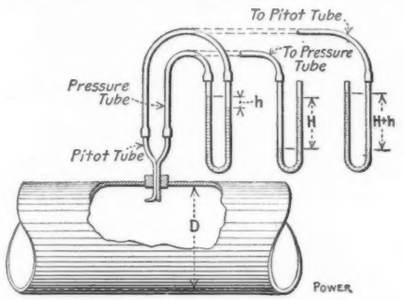


FIG. 3. DEVICE FOR MEASURING PRESSURE IN PIPE

These two impellers, however, served to demonstrate the proposition as intended and further illustrate the fact that it is not possible to determine the horsepower required for a given blower, when only the diameter, width of blades and the number of revolutions per minute are known. It is necessary to know also the inlet and outlet angles of the vanes, the equation of their form, and the equation of the areas of passage from the inlet to the outlet of the impeller.

It is true that for a certain line of standard machines it is possible for the manufacturer to establish a set of approximate horsepower curves which are very useful for estimating; but such information is never given to the user of the machines.

When the fan takes the air from the atmosphere and delivers into a duct, and particularly when that duct or pipe is circular, it is comparatively easy to measure the approximate capacity of the apparatus when the air handled is at a moderate temperature. The instrument needed for the operation is very simple and can be easily made. Fig. 3 represents a combination of Pitot and pressure tubes connected to a glass U-tube containing water. The end of the assembled tubes should be inserted into the delivery pipe as shown. A straight part of the pipe should be selected where the flow is not likely to be disturbed by the influence of bends, valves, etc. The gage should be inserted into the pipe for about one-sixth the diameter and turned so that the open end of the Pitot tube is against the current. If the tube is not so placed the readings will not be correct.

With the two rubber tubes in place the difference in the hights of the columns of water in the U-tube shows the velocity head causing the flow in the duct. Disconnecting the Pitot tube from the glass gage and measuring the hight between the two levels, will indicate the pressure head against which the air is delivered. Again connecting the Pitot tube and disconnecting the pressure tube, will show, by the difference in the hights of the water columns, the total head produced by the fan. This total head is composed of the static head measured by the pressure tube, plus the velocity head shown when the two tubes are used together.

Calling the velocity of flow v feet per second, the velocity head h inches of water, and the static pressure head H inches of water,

$$v = \sqrt{2g\frac{p}{d}} = \sqrt{\frac{1{,}746{,}700 \times h}{406.7 + H}} = 1321\sqrt{\frac{h}{(406.7 + H)}}$$

where,

p = Pressure in pounds per square foot;

d = Weight, in pounds, of one cubic foot of free air at 50 degrees Fahrenheit = 0.077884;

406.7 = Inches of water corresponding to atmospheric pressure.

Knowing the inside diameter D, in inches, of the delivery pipe, the volume discharged in cubic feet per second is

$$\frac{\pi D^2}{4 \times 144} \times v$$

But this air is at a pressure H and the corresponding volume of free air per minute would be

$$\frac{\pi D^2 \times v \times 60 \times (406.7 + H)}{4 \times 144 \times 406.7} = \frac{D^2 \times v \times (406.7 + H)}{1242}$$

cubic feet per minute

The horsepower in air delivered would be

$$\frac{\textit{Volume per minute} \times \textit{pressure per square foot}}{33{,}000}$$

One cubic foot of water weighs 62.35 pounds; one inch of water equals

$$\frac{62.35}{12} = 5.196 \textit{ pounds per square foot}$$

Hence,

$$\frac{\textit{Volume per minute} \times 5.196 \times H}{33{,}000} = \textit{Air horsepower}$$

or

$$\textit{Air horsepower} = \frac{\textit{Cubic feet per minute} \times H}{6350}$$

Substituting for the volume and velocity their respective values:

$$\textit{Air horsepower} = \frac{D^2 \times v \times H \times (406.7 + H)}{6350 \times 1242} =$$

$$D^2 \times H \times \left(1321\sqrt{\frac{h}{406.7 + H}}\right) \times (406.7 + H) = \frac{D^2 H \sqrt{h \times (406.7 + H)}}{5970}$$

As the efficiency of ordinary blowers is about 50 per cent., multiplying the air horsepower as just obtained by 2 gives approximately the shaft horsepower necessary to run the blower. While reading the gages the speed should be kept constant, and the time selected when the flow of air is uniform.

The gage readings and particularly that of the velocity head should be very close, for which reason it is preferable to use a U-tube of rather small diameter.

The formulas herein given are intended for approximate work only. The density of the air depends so much upon the temperature that the method would not apply to hot-blast work, for instance. Corrections should also be made for altitude and humidity. However, if the proper constants were determined to suit a given installation, the formula as modified would be found very useful.

Defects in Welded Flanges

In a paper presented at the May meeting of the Iron and Steel Institute by

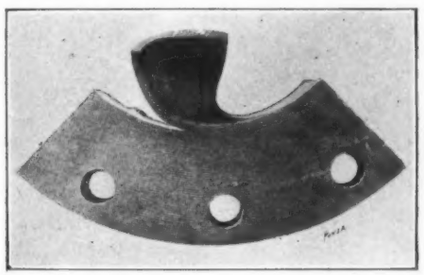


FIG. 1. METAL STRIPPED BY DRIFTING TOOL, SHOWING NO FUSION

FIG. 2. SECTION THROUGH COKE-FIRE WELDED PIPE

Messrs. Law, Merrett and Digby, some interesting facts are brought out regarding welded flanges. Two cases were considered, one a coke-fire weld and the

other an arc weld, the observations of which serve to substantiate the stand taken by many consulting engineers in steadfastly refusing to employ welded flanges.

A welded pipe flange may be obviously mechanically imperfect, or it may be apparently perfect and capable of withstanding hydraulic-pressure tests. In the latter condition ignorance as to its internal condition produces a peace of mind which knowledge is liable to destroy.

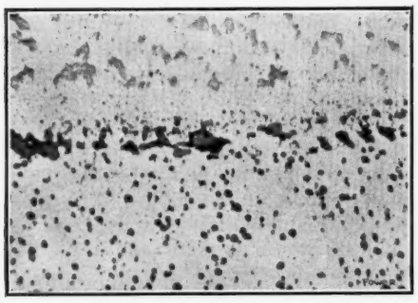


FIG. 3. SLAG ALONG TRACK OF WELD

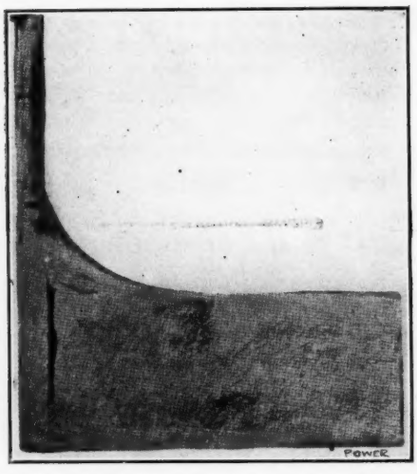


FIG. 4. ARC-WELDED FLANGE AFTER BEING SAWED AND ROUGHLY FILED

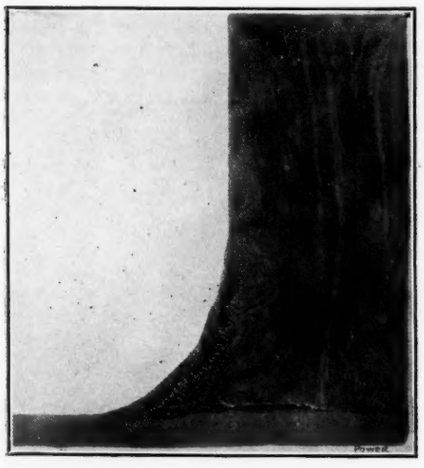


FIG. 5. ARC-WELDED FLANGE SHOWING DEMARCATIONS

Fig. 1 shows the segment of a wrought-iron flange nominally welded to a mild-steel pipe by the coke-fire process. As shown, it has been stripped away by the use of a drifting tool, and as there is no fusion of the metal it is only nominally welded. Fig. 2 shows another portion of the segment in which the pipe has not been mechanically forced away from the flange. The clear demarcation of the area shows that there has been no fusion of the metal. Fig. 3 shows, at one hundred magnifications, an accumulation of slag in the form of silicate along the track of the weld.

A segment of an arc-welded flange on a steel pipe is shown in Fig. 4, just as it had been sawed and roughly filed. It will be noted that the weld is only partial, over one-third of the area of junction having an air space. This pipe would probably have passed a reasonable hydraulic test and its defects would have been discovered only in service.

Fig. 5 represents the same view of the segment after polishing and etching. The excessive action of the corroding medium upon the area on which the arc has played, and the abrupt termination of these areas, are clearly shown.

Determining the Most Economical Vacuum

BY THOMAS H. BROCKMAN

Assume a vacuum of 28 inches in the condenser. If this is reduced to 24 inches there will be a difference of some 40 degrees in the temperature of the hotwell. If this difference could be added to the temperature of the feed water it would mean a saving of about 3½ per cent. in the amount of fuel required to evaporate the same quantity of water.

Reducing the vacuum reduces the mean effective pressure in the cylinder and increases the temperature of the feed water. One means a loss and the other a gain. At what point do gain and loss so balance that an increase or decrease of the vacuum means loss? This question appeared in POWER a while back. In my spare moments I have been endeavoring to figure out what it all meant. The result shows the relation that exists between the temperature of the steam and the pressure.

Assume an indicator diagram as shown in Fig. 1 with the following:

$P_1 = 91$ pounds absolute;

$V_1 = 1, V_2 = 4, V_3 = 0.5, Vc = 0.04$;

r = Ratio of stroke to cutoff $= 4$;

rc = Ratio of volume at exhaust closure to clearance volume

$$= \frac{0.5}{0.04} = 12.5;$$

P_x = Some vacuum to be assumed;

P_y = Some vacuum to be assumed.

Then, the mean effective pressure of the indicator diagram equals

$$\frac{\left(\begin{array}{c}P_1V_1\,(1+log.\,r) - P_xV_4 - P_1Vc - P_x \\ (V_2 - V_4)\,log.\,r\end{array}\right)}{(V_2 - Vc)}$$

Now, suppose that the vacuum has been reduced to P_y. Then the per cent. loss due to the increased pressure in the condenser will be,

$$\frac{\left(\begin{array}{c}P_1V_1\,(1+log.\,r) - P_xV_4 - P_1Vc - P_x \\ (V_2 - V_4)\,log.\,rc - (P_1V_1\,(1+log.\,r) - \\ P_yV_4 - P_1Vc - P_y\,(V_2 - V_4)\,log.\,rc)\end{array}\right)}{\left(\begin{array}{c}P_1V_1\,(1+log.\,r) - P_xV_4 - P_1Vc - \\ P_x\,(V_2 - V_4)\,log.\,rc\end{array}\right)}$$

which reduces to,

$$\frac{4.725\,P_x - 4.725\,P_y}{213.26 - 4.725\,P_x} = \textit{per cent. loss of mean effective pressure} \qquad (1)$$

If H= total heat in the steam at 91 pounds, and t_x = temperature of steam

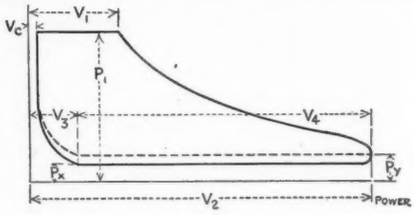


FIG. 1

corresponding to pressure P_x, t_y = temperature of steam corresponding to pressure P_y, and assuming that the temperature of the feed is the same as the temperature of the hotwell, the per cent. gain of fuel required to evaporate the same amount of water will be,

$$\frac{H - (t_x - 32) - (H - (t_y - 32)}{H - (t_x - 32)}$$

If $P_x = 1$ pound, $H = 1113.1, t_x = 102$; therefore,

$$\frac{t_y - 102}{1043} = \textit{per cent. gain in fuel} \qquad (2)$$

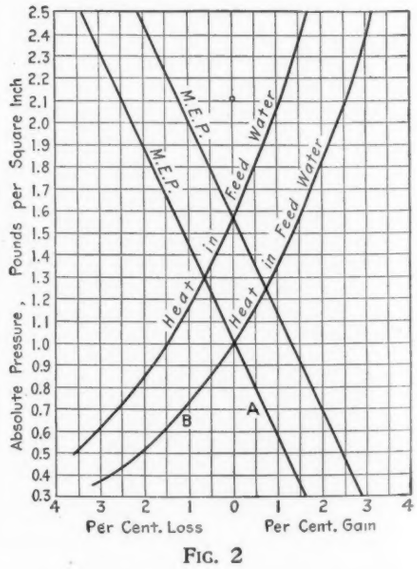


FIG. 2

By choosing values for P_y above and below 1 pound absolute in (1) and (2), the curves (A) and (B) in Fig. 2 were drawn. It was found by using two or three values for P_x that the curve (A) remained a straight line, while (B) only shifted to the right or left as P_x was increased or decreased. It will be seen

by referring to Fig. 2 that there are two pressures at which the loss and gain are equal, at 1 pound and at 2.11 pounds. Any pressure below 1 pound means a loss and any pressure above 2.11 pounds means a loss. Therefore, halfway between these two points is a pressure where loss and gain so balance that any increase or decrease of pressure means a loss. This is shown by the two curves that pass through 1.56 pounds. They were platted by taking P_x equals 1.56, and choosing values of P_y above and below P_x.

Curves (A) and (B) show at a glance between what pressures a vacuum can be maintained without a loss. Of course, the foregoing is theoretical. The temperature of the hotwell is never the temperature of the feed water, but a few observations would give this relation.

Wave Motors and Compression

By F. L. Johnson

"This is he bald-head section. I have segregated these specimens for the purpose of collecting data on the growth of hair on wood," said the "Old Man" to a companion, as he swung open the door of our "box stall" one pleasant winter day. The door swung back as he passed on and it was not noticed that someone had entered, until, with a pleasant New Hampshire drawl, the visitor said:

"I suppose that is the way John A. expresses his appreciation of your efforts to keep on the pay roll. Well! All soils will not grow both hair and brains at the same time." It was Sawyer, and his trim, well-dressed figure, clean-cut face, alert glance and half satirical smile looked good to all of us. After shaking hands all around, exchanging the usual midwinter holiday greetings and good wishes, his attention was monopolized by the Dean, who always takes upon himself to settle offhand all questions, financial, social and ethical. He eliminates the other fellow by starting in first and keeps at it until all of the available time, as well as the listener's, is exhausted.

"I see that Professor Heck," he started this time by saying, "has taken most of the wind out of the sails of the noncompressionists, which, of course, includes you and Dwelshauvers-Dery. Mr. Heck is undoubtedly right for, as he says in the issue of September 13 and again in that of December 27 in his reply to Dery's criticism that"—Just here one of the counter girls announced that a gentleman was waiting in the library to see the dean.

"I saw an old friend of mine at Atlantic City the other day," Sawyer turned to me and said as the dean left the room, "in the form of the United States Wave Power Company's wave motor. You doubtless have not forgotten what I told you of boyhood experiences years ago at the foot of Gas House road. One of our motors was made by loading a 50-gallon tar barrel with about 400 pounds of water and running a rope from it over a sheave and around a drum fastened to the overhead timbers of the coal shed.

"A counterweight made by filling a bag with sand was fastened to the end of the rope which passed over the drum. On one end of the drum shaft there was a crank from which a connecting rod led to the handle of a twin-cylinder force pump. The whole apparatus was like this." As he talked along, he rapidly sketched a picture of his boyhood achievement in the wave-motor line.

"The pump was submerged for the purpose of making it reliable. No air leaks in the suction pipe could interfere with the flow of water to the cylinders, nor could air collect in the clearance spaces and keep the water out.

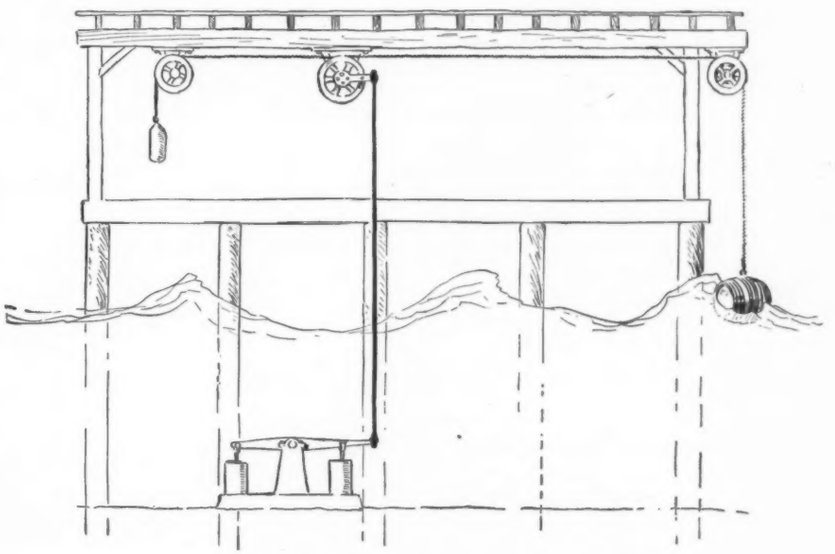
"Any movement whatever of the pump pistons forced some water up through the discharge pipe, which we designed later to connect with an elevated tank from which a stream could be drawn to run a small waterwheel. The thing would pump and I think it developed as much as one full catpower.

"There was a rise and fall of the tide of about eight feet which was all utilized in operating the pump as well as the rise and fall of the little waves; any movement of the barrel, whether vertical, horizontal or at any angle, was sure to move the pump pistons though a part of a stroke and a complete revolution of the drum corresponding to a rise or fall of the barrel through a space of about 18 inches would give a full stroke to the pump. It would do its best work when the waves rolled in at a hight of about two feet.

"At Atlantic City the machine is quite complex, and the same provision is made for all sorts of movement of the floats which furnish the power that I had, only they are more elaborate.

"A barker explained the operation to me and gave me some of the details. He said the floats weigh approximately 3000 pounds each and that the six floats would, with 2-foot high waves coming at the rate of eleven per minute, give an output of 120 horsepower. No one tried to sell me any stock and I came away mentally computing how much power could be gotten from the fall of six 3000-pound floats through a distance of two feet eleven times a minute. As all the energy that the floats could give up was that of falling from the hight to which the waves lifted them, I concluded that the claim of 120 horsepower from this machine was about 2000 per cent. higher than a reliable dynamometer would register."

Just here the dean returned and as he was about to start in again at the point where he was cut off, Sawyer said to him.



Sawyer's Wave Motor Made in Boyhood Days

"I have read both of Mr. Heck's contributions to the defense of his untenable premises. He practically begins by saying that Boyle's law does not apply to steam and then uses deductions from this same law to prove untrue what Dwelshauvers-Dery knows and what every engineer who has tried it knows to be true. He gets all tangled up in the labyrinth of his own logic and finally admits that more than a little compression may not be economical.

"It is not a question of vital importance but it is one that cannot be settled by discussion; and so long as mechanical engineers who have the equipment necessary for an exhaustive and conclusive test prefer argument to experiment, I shall believe that no one dares to try it. I have tried it on a commercial scale and know that compression costs money,

while not one of all the talented and educated gentlemen who believe otherwise has ever made even laboratory experiments, nor do I think they ever will.

"Something along this line may be done by the United States Geological Survey, but by any educational institution now flooding the country with sheepskin mechanical engineers, Nit.

"I am sorry I cannot stay the rest of the afternoon and tell you of several interesting little experiences in this line, but I must leave you for today." And without giving the dean, who had been on nettles all the while Sawyer was talking, time to put in a word, he winked to Rogers as he buttoned his overcoat and, saying good-by, went to the elevator.

Overcoming a Pound in the Cylinder

By A. J. Dixon

A pound caused by a loose liner in the high-pressure cylinder was stopped by placing setscrews between the end of the liner and the cylinder head, thus keeping the former in place.

The power equipment of a newly erected electric-railway generating station included a cross-compound condensing Corliss engine. About a week after this engine had been put in commission for regular service, a peculiar pound was noticed, but could not at first be located in any particular part of the machine. The pound was indistinct and scarcely noticeable at the beginning, but became more and more pronounced as the days passed. The various adjustments of crossheads, wrist- and crankpin brasses, main bearings, etc., having all been carefully attended to without producing any mitigating effect, the engineer finally decided to refer the trouble to the firm which supplied the engine. The manufacturers, accordingly, despatched the designer of the engine, together with a machinist and the engineering salesman, to look into the matter. By the time this trio appeared upon the scene, the pound had so increased as to leave no doubt that its origin was somewhere on the high-pressure side of the engine, with the indications pointing strongly to the cylinder end of the structure.

After pottering around for some time, the coterie of experts concluded that the source of the trouble lay in the connection between the piston rod and the crosshead. The rod was accordingly disconnected, the operation involving much time and labor, owing to peculiarities of construction, and then the parts were carefully put together again. However, when the engine was started again the pound was just as prominent as before. As this unit was the only one available for service at the time, it was imperative that it run until the next day, when the experts again went at it. This time they removed the caps from the main bearings, took out the quarter boxes and, finding nothing wrong, put them back again and started up, but with the same result. This procedure went on for several days, the experts tinkering first with one part and then with another, taking out the piston follower and packing rings and putting them back again; tightening every bearing, etc., but without any abatement of the pound which, on the contrary, continued to increase.

The high-pressure cylinder, which had a diameter of 24 inches, contained a steel liner, as shown in Fig. 1. It was claimed that this liner, which was 1¼ inches thick, had been set in the mold and the cylinder barrel cast around it, the steel thus becoming fused with the molten cast iron. The engineer advanced the supposition that this liner was probably the cause of all the trouble. The designer and his associates declared this to be utterly impossible, stating with much emphasis that inasmuch as the steel liner was not separate from the iron cylinder barrel it could not be the cause of the disturbance, as the mere fact of it becoming loose would mean a broken cylinder.

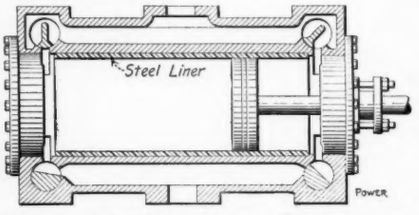


FIG. 1. SECTION THROUGH CYLINDER BEFORE MAKING REPAIR

Nevertheless, the engineer steadfastly maintained that as every other part of the machine, in which a pound of this nature might possibly originate, had been inspected and nothing had been found amiss, the only logical thing to do was to inspect the liner.

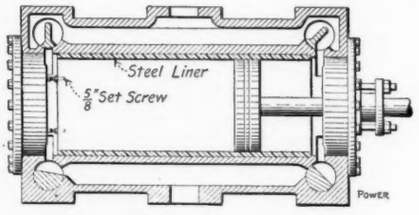


FIG. 2. CYLINDER SHOWING SETSCREWS HOLDING LINER

As the pound continued to increase at an alarming rate, keeping pace with the strokes of the piston with occasional muffled lapses as it apparently missed a stroke, the engineer finally concluded to take the matter into his own hands. Accordingly, he removed the cylinder head, ran out a timber with a screw jack behind it, between the edge of the bushing and the wall of the room, tightened up on the jack, and, as anticipated, the liner was found to be loose. Consternation reigned for a moment among the engine company's representatives, for it appeared at first that the only way to restore the engine to good order was to put on a new cylinder. The designer soon recovered his equilibrium, however, and began to devise plans for a serviceable repair with the least possible expense and delay. It was finally decided to patch the cylinder as shown in Fig. 2.

The edge of the liner was drilled at four equidistant points, the holes threaded by ⅝-inch standard taps, and case-hardened setscrews secured with locknuts, were inserted as shown. The liner was forced firmly against the shoulder at the crank end of the cylinder, and then the setscrews were so adjusted that their heads bore solidly against the face of the cylinder head, at the same time permitting steam-tight contact in the ground joint between the head and the cylinder. This was a rather delicate adjustment and necessitated a dozen or more removals and replacings of the cylinder head before completion.

The engine continued in service and ran fairly well with this arrangement, but the engineer had a tedious job on his hands every Saturday night readjusting the setscrews after the previous week's run, for the thrust on the liner at each return stroke of the piston naturally tended to ram the screw heads hard against the cylinder head, wearing recesses in the comparatively soft metal and permitting a slight shuttling of the liner and the reappearance of the original pound.

A 16-horsepower internal-combustion motor is being tried for underground traction in the Langlaagte Deep mine, Transvaal. A special form of exhaust condenser is used, in which part of the cooling water is used to condense the products of the explosion, so that the vitiation of the air is stated to be less than would be the case if the many men required to deal with the load were at work.

Test of a High-Duty Pumping Engine

By Prof. R. W. Angus

The results of a twenty-four-hour duty trial on a new triple-expansion pumping engine at the Toronto city water works.

The supply of water for the city of Toronto is drawn from Lake Ontario, the water first passing through a steel pipe from the intake to Toronto island and thence through a large concrete tunnel under the bay to the well at the main pumping station. The tunnel is some distance below the bed of the bay so as to avoid seepage from the bay.

The engines of the main pumping station deliver directly to the mains, but the pressure is limited, due to the fact that a reservoir forms part of the system and is located at the opposite side of the city from the pumping station. The pressure maintained on the discharge main by the pumps at the main station is about 100 pounds per square inch.

The ground rises steadily from the bay northward through the city, and at the northern part, due to the high elevation, the water pressure is so far reduced as to make it necessary to provide some means of increasing it materially in order to furnish a satisfactory domestic supply. Hence, a high-level station was erected in which the pumps receive water direct from the mains supplied by the main pumping station, and discharge it into a separate system which serves the region named. The growth of this part of the city has been so rapid within the last few years, however, that it was found necessary to increase the equipment of the high-level station by the addition of new pumps, and it is to one of these that the present article refers.

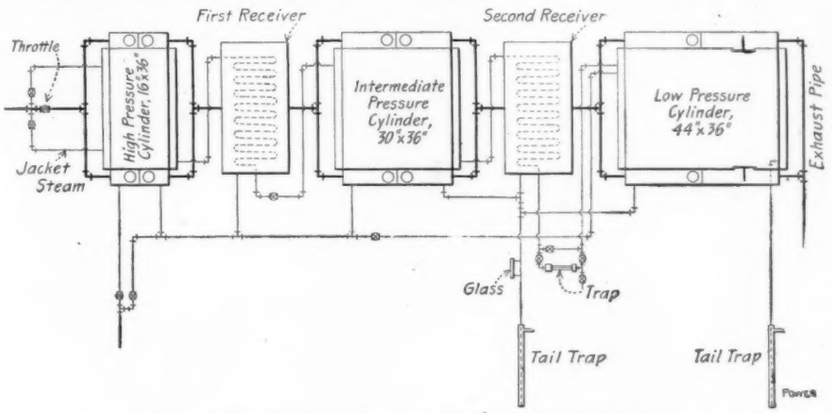


FIG. 1. DIAGRAM OF ENGINE CYLINDERS AND PIPING

This pumping engine was built by the John Inglis Company, of Toronto, and is of the vertical, triple-expansion crank and flywheel type with three single-acting plungers and has a capacity of six million imperial gallons per 24 hours against a discharge pressure of 75 pounds per square inch, the suction pressure being 20 pounds. Dry saturated steam is supplied at a boiler pressure of 150 pounds.

A diagram of the steam cylinders and piping showing the path of the steam for the jackets, coils and cylinders is shown in Fig. 1. There are three steam cylinders, each of which is jacketed on the barrel only, but the design is such that the steam entering each cylinder passes over one-half of the corresponding head while the exhaust from the cylinder passes over the other half of the same head.

Corliss valves with separate eccentrics for steam and exhaust are used in all cases, except the exhaust from the low-pressure cylinder, where flat valves are used. The latter are opened by cams, the top pair being closed by compressed air and the lower ones by gravity. The exhaust steam may be passed through a feed-water heater on its way to the condenser if desired.

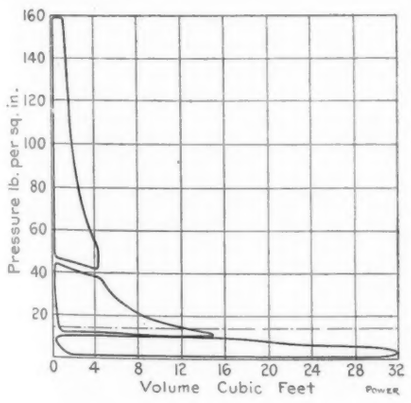


FIG. 2. COMBINED DIAGRAM, HEAD END

The air pump, boiler-feed pump and air compressor are attached to the low-pressure plunger, the compressor furnishing air for closing the low-pressure exhaust valves and also for replenishing the air in the pump-discharge chambers.

TABLE 1. PRINCIPAL RESULTS OF THE TRIAL

Pressure at engine, pounds	148.5
Pressure in first receiver, pounds	29.9
Pressure in second receiver, pounds	1 (below atmosphere)
Pressure in intermediate jacket, pounds	30.8
Pressure in low-pressure jacket, pounds	1.8
Vacuum, inches	28.3
Barometer, inches	29.38
Net pressure on pumps, pounds	54.90
Temperature of engine room, degrees Fahrenheit	60
Moisture in steam, per cent	0.3
Average speed, revolutions per minute	29.32
Average plunger speed, feet per minute	175.8
Plunger displacement per 24 hours, imperial gallons	6,040,368
Work done per 24 hours, foot pounds	7,662,342,570
Water horsepower	161.2
Steam used in jackets, etc., pounds	6,806.5
Steam condensed in condenser, pounds	40,077.5
Total steam used per 24 hours, pounds	46,884
Steam used per water horsepower per hour, pounds	12.1
Duty in foot-pounds of work done per 1000 pounds of steam used	163,431,900

There are three outside-packed, single-acting plungers of 21⅝-inch nominal diameter, the pump having a 24-inch suction and a 20-inch delivery pipe. All the water pumped passes through the surface condenser and is used as cooling water. The principal dimensions of the engine are as follows:

Cylinders	16, 30 and 44x36 inches
Diameter of piston rods, inches	4¼
Clearance varies from: top end, high-pressure cylinder, per cent	1.85
Clearance varies from: to bott'm end, low-pressure cylinder, per ct.	0.89
First receiver, inches	25x66
Second receiver, inches	36x66
Condenser, cooling surface, square feet	372

DUTY TRIAL

A 24-hour duty trial of the engine was recently conducted by the writer. According to the contract the engine was to show a duty of 160,000,000 foot-pounds of work per 1000 pounds of steam used by the engine and auxiliary pumps, the steam to contain not over 1½ per cent.

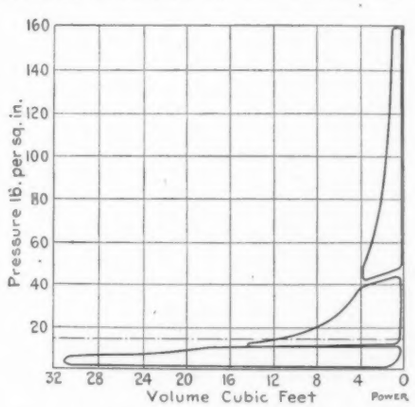


FIG. 3. COMBINED DIAGRAM, CRANK END

moisture and to have a pressure of 150 pounds at the boiler, this pressure corresponding to 148.5 pounds at the engine.

Without going fully into the method of making the test it may be stated that great care was taken in getting the exact diameters and strokes of the several plungers, and special care was taken with other quantities used in computing the duty so as to insure accuracy in the results.

The water pressure averaged 74.92 pounds on the discharge main and 20.02 pounds on the suction main, and as these pressures were maintained very steady and the readings taken at five-minute intervals during the trial, these readings represent quite closely the true results. Table 1 gives the principal results of the trial.

This represents an extremely good performance in view of the fact that the power of the engine was so small, due to the low net water pressure. A set of combined indicator diagrams is given in Figs. 2 and 3 which show very good steam distribution.

Corrosion of Steam Boilers

By Walter C. Edge

Some of the common impurities found in feed water, their corrosive and scale-forming qualities, and the simple methods of treatment.

Water in a natural state always contains a great many other things than two parts hydrogen and one part oxygen. Sometimes it contains free nitric and sulphuric acids. River water, as a rule, is heavily loaded with vegetable and organic matter; nearly all lake waters contain limestone, and artesian and spring waters often contain soda as well as other foreign matter. These mineral substances are dissolved by the water in passing through the soil. The weight of the impurities in water varies greatly, but in moderately good water it is often from 20 to 50 grains per gallon. An analysis of a certain feed water showed it to contain the following impurities:

	Grains per Gallon
Silica	0.105
Oxide of iron and aluminum	0.362
Carbonate of Magnesia	13.794
Carbonate of lime	11.481
Sodium and potassium sulphate	3.569
Sulphate of lime	trace
Sodium and potassium chloride	3.300
Total solids	32.611

The total solid matter amounted to 4.65 pounds per 1000 gallons. A grain is 0.007 of a pound; hence, a steam boiler evaporating 600 gallons per hour (about 160 horsepower) would collect a deposit of

$$\frac{600 \times 4.65}{1000} = 2.80 \text{ pounds}$$

This is the approximate amount of impurities collected in one hour. Part of this would form sludge and the remainder would be converted into hard scale. If this boiler were worked a week of 60 hours, 168 pounds of solid matter would collect, and in less than three months this would amount to more than a ton.

The following table shows the principal impurities to be found in waters, some of them being in all waters and all of them being in some waters:

Impurities	Causing
Sulphate and bicarbonate of lime	Hard incrustation
Sulphate, chloride and bi-carbonate of magnesia	Incrustation and corrosion
Chloride of sodium and carbonate of soda	Priming, foaming and incrustation
Bicarbonate and peroxide of iron	Incrustation and corrosion
Dissolved carbonic acid and oxygen	Corrosion
Sediment, mud, clay, etc.	Incrustation
Organic matter, sewage, etc.	Priming and corrosion
Grease	Corrosion
Nitric and sulphuric acids	Corrosion

The scale in a boiler is formed by lime, chalk and iron. While these solids are in solution in the original waters and cannot be detected by the eye, yet they are always left behind by the steam, and accumulate rapidly unless some means are taken to get rid of them.

Some of the evil effects of impure feed water are loss of fuel, loss of power and danger. The loss of fuel caused by a coating of scale on the heating surfaces of a boiler varies considerably, because it depends on the composition of the scale; some scales resist the transmission of heat many times as much as a boiler plate of the same thickness. It has been estimated that there is a reduction of from 2 to 4 per cent. a week in the quantity of water evaporated per pound of coal, due to the accumulation of scale. According to this, a boiler after working for four weeks would probably evaporate 8 to 16 per cent. less water per pound of coal than when in a clean condition, thus showing how important it is for the boilers to be kept clean.

If the feed water is of a corrosive nature it is advantageous to permit the formation of very thin scale as a preventive against corrosion. Corrosion, or the wasting away of the plates, is caused mostly by gases absorbed by the water, such as sulphurated hydrogen, and carbonic acid; grease and organic matter also promote corrosion. Even the purest waters when containing air, will cause pitting. More or less air is found in all waters, and this air escapes into the steam space when liberated by boiling, and being heavier than the steam, collects in bubbles, forming a layer between the water and steam and rapidly corroding the plate in the vicinity of the water line. The engineer should be careful to prevent the feed pump from drawing air, and should also be on the alert to prevent valve stems, etc., from leaking water on top of the boiler, as a great number of cases of external corrosion have been caused by a little neglect or carelessness regarding small leaks.

No doubt much corrosion in boilers is due to galvanic action; that is, when two different metals are placed in a solution capable of acting chemically on both of them an electric current is set up. The metal which is rapidly attacked and wasted away is known as the positive electrode, and in a galvanic battery, iron is always positive in the presence of copper. The inactive plate is known as the negative electrode. Iron is both positive and negative in the absence of other metals. In the presence of zinc, however, iron becomes negative.

Zinc then effectively protects iron from one form of corrosion. The presence of a small quantity is sufficient, a good proportion being a 12x6x½-inch slab for every 70 boiler horsepower. These slabs are usually attached to a stay, and should be renewed at regular intervals. Galvanic action is not nearly so common as some people seem to think, and it is doubtful if the action on the zinc slabs is always electrical, yet, if the corrosion of the boiler plates is lessened, their use should be continued even though the action is not fully understood.

In every section of the country the water has a different class of impurities, but the most common are the lime and magnesia. These substances are the principal cause of incrustation (hard scale formation) in boilers. Carbonate of lime (marble) and magnesia are almost insoluble in pure water, but dissolve readily in water containing carbonic-acid gas. This gas is driven off by boiling, and the lime and magnesia, before held in solution, are thrown in the solid form as insoluble deposits. A part of the mineral matter is deposited in the form of a fine powder, which forms mud, and the remainder settles on the plates of the boiler as hard scale.

The impurities are not all set free from the water at the same temperature. Thus the carbonates of lime are precipitated when a temperature of from 300 to 400 degrees Fahrenheit (corresponding to about 150 pounds pressure) is reached.

The small solid particles when set free remain for a time suspended in the water, being carried around by the circulation, but they settle down gradually on the

tubes, plates and other internal surfaces. The lime matter then becomes scale, which soon bakes to the plates, and if no means of prevention are used a crust from $\frac{1}{16}$ inch to $\frac{1}{2}$ inch thick is formed on the inner surface of the boiler.

A good feed-water heater will serve to keep out the impurities which precipitate at temperatures in the neighborhood of 200 degrees Fahrenheit; this includes both the carbonates of lime and magnesia. The water will not hold these solids in solution when it is at 200 degrees or more, and consequently they are precipitated. But they are still held suspended in the water, and, unless given time to settle, will go to the boiler just as they would if still in solution. For this reason all purifiers should have space for from 5 to 15 minutes' supply of feed water.

Soda is the common antidote for carbonates of lime and sulphates of lime, the two most common impurities of water. Under the name of soda several substances are used as preventives of scale in steam boilers. The cheapest and most common is carbonate of soda, commonly known as soda ash. When soda ash is crystallized by dissolving in water, it becomes sal soda, which is synonymous with washing soda. Caustic soda is made by heating carbonate of soda with slacked lime. A solution of caustic soda in water is known as soda lye. For ordinary cases, 40 pounds of soda ash, 60 pounds of sal soda or 35 pounds of caustic soda per 1000 gallons of water will be sufficient to precipitate most of the scale-forming matter.

The cost of treatment with soda is very low, only about one grain of soda ash being required for each grain of sulphate.

If there are any free acids present they should be neutralized by additional soda. An excess of soda will impair the steaming facilities and will also have a corrosive effect on the iron. This is indicated by foaming, leaks, and the white salts of sodium oozing through the joints.

Boiler Plant Considered as a Factory

By Paul A. Bancel

Considering the coal, water and air as raw materials and steam as the finished product, the various losses in the process of manufacture are traced. The value of a CO_2 recorder for indicating these losses is discussed.

A boiler plant may be considered as a factory for making steam, from which standpoint an increase in boiler efficiency represents a decreased cost of production of the finished product—steam.

The raw materials supplied to the steam factory are coal, water and air. Of these, coal is expensive; water is expensive in some cases, but as the amount of water used is the same per pound of steam turned out, practically regardless of the method of operating the plant or its efficiency, it may be omitted at the outset from this discussion; finally, the third material, air, costs nothing except to move it.

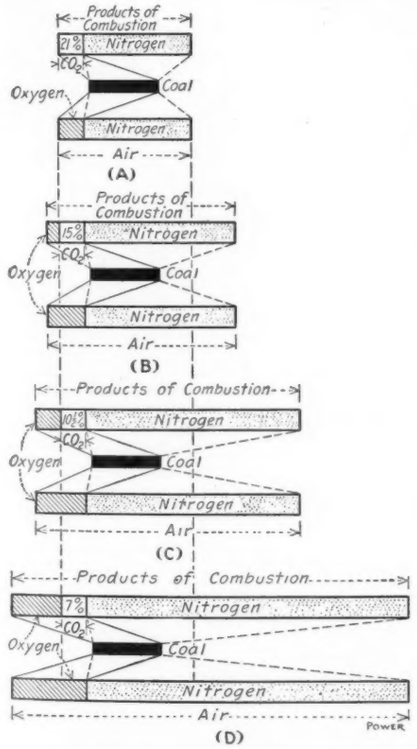


FIG. 1. GRAPHICAL REPRESENTATION OF PRODUCTS OF COMBUSTION AND EXCESS AIR

The process of making steam may best be analyzed in two steps: First, the combination of the coal and air to form hot gases; second, the transference of the heat in the hot gases to the boiler surfaces, thence to the water and the formation of steam.

As with any other process of manufacture, there are wastes occurring in both steps of the process. These wastes occur due to the imperfect nature of the machinery used, the imperfect use of the materials, the formation of a waste product and the fact that the best of labor is careless. The waste or losses occurring in the process of making hot gases out of coal and air, may be summarized for the average plant as follows:

	Per Cent.
Loss due to unconsumed carbon or smoke	1
Loss due to unburnt combustible gases, such as hydrogen and carbon monoxide and hydrocarbons	2
Loss due to unconsumed carbon dropping through the grates with the ash	2
Loss due to radiation	5
Total losses	10

As is seen, the sum of all these losses amounts to 10 per cent. of the heat in the coal. If all the heat in the hot gases could be transferred to the water in the boiler, efficiencies of 90 per cent. or better would be obtained. It is in the second step of the process of steam manufacture that is found the chief cause of low efficiency.

The water within a boiler is at some temperature near 400 degrees Fahrenheit. The hot gases give up part of their heat to the water within the boiler, and are cooled down an amount depending upon the amount of surface used. If boilers were very large, then it would be possible to cool the gases to nearly the temperature of the steam and water. Unfortunately, it does not pay to put so much surface into a boiler, and gases are emitted from the chimney at temperatures near 500 or 600 degrees Fahrenheit. Thus the hot gases formed in the first part of the process with an efficiency of 90 per cent., are of no use for making steam under ordinary conditions, when their temperature has dropped below 500 or 600 degrees Fahrenheit. These gases are then a waste product of the steam factory, but not necessarily a useless product. They are valuable for heating cold water, cold air, for making draft in a chimney and for evaporating a liquid such as ammonia.

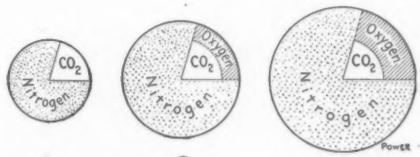
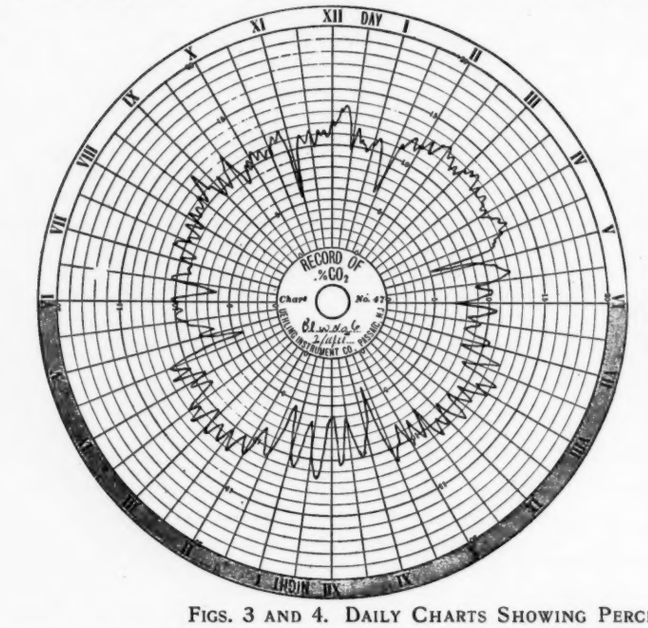


FIG. 2. COMBUSTION DIAGRAM

The amount of heat carried away from the boiler plant depends evidently upon the temperature of the gases, their specific heat and their weight. The specific heat is practically constant at 0.23 but the weight of the gases depends on how much air is used to burn the coal. Calculations will show that the heat value of the waste product in a boiler plant may run as high as 30 per cent. of the total heat of the coal. The very nature of this loss makes direct measurement difficult. If it were possible, the best method of determining the amount of

heat in the waste gases would be to take the temperature of the gases going up the chimney and to measure their weight for each pound of coal burned.

The weight of the gases going up the chimney, however, cannot be readily measured and it is difficult to determine just how much coal is actually being burned at any time corresponding to the moment at which the weight of the gases is taken. There is no direct means, therefore, of measuring the amount of heat in the waste product emitted from the steam factory, or boiler plant. On the other hand, an indirect means of obtaining the weight of the waste product per pound of coal burned lies in the measurement of the carbon dioxide contained in the flue gases.



FIGS. 3 AND 4. DAILY CHARTS SHOWING PERCENTAGES OF CO_2 AND THE FLUE TEMPERATURES

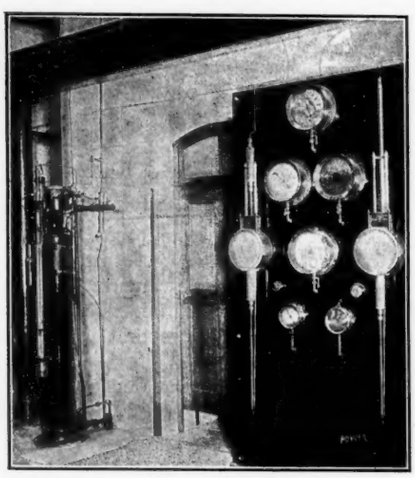


FIG. 5. UEHLING WASTE METER AND RECORDING GAGES

Air consists of oxygen and nitrogen. Only oxygen is necessary for combustion, but the nitrogen must be carried along with the oxygen into the furnace without entering into the process of combustion. Coal consists of carbon, hydrogen, ash and minor constituents, the first two entering into the process of combustion, the latter being mineral material not combining with the oxygen and not developing heat. The carbon in the coal combines with a definite amount of oxygen to form carbon dioxide gas or CO_2. Furthermore, it is an established fact that when a cubic foot of oxygen combines with carbon to form carbon dioxide, the volume of the carbon dioxide formed is also one cubic foot, the temperature of oxygen and carbon dioxide being the same. As the volume of all the gases varies in the same way with the temperature changes, any volumetric relations holding true when the temperature of the products of combustion as 500 or 600 degrees will also hold true when their temperature is that of the atmosphere.

Referring to Chart A, Fig. 1, assume that the coal consists of carbon only and below the coal bed a certain amount of air consisting of oxygen and nitrogen is supplied, the coal burning so that the products of combustion consist of carbon dioxide and nitrogen. If the combustion were complete with just enough air supplied to effect complete combustion, then as the carbon dioxide displaces the oxygen, the volumetric relations of the gases in the products of combustion would be the same as the relations of the gases in the air. The percentage by volume of oxygen in the air is 21, and with theoretically perfect combustion of carbon, the products would consist of 79 per cent. of nitrogen, 21 per cent. of carbon dioxide and no percentage of oxygen. Charts B, C and D, Fig. 1, show the relations when more than the theoretical amount of air has been supplied. The amount of coal burned being the same, the same amount of carbon dioxide must be formed. But as more than the theoretical supply of air has been furnished, a part of the oxygen, together with all the nitrogen, must go through the coal without entering into the process of combustion. The products of combustion consist then of nitrogen, carbon dioxide and also a supply of uncombined oxygen. If twice as much air and oxygen as is theoretically needed were supplied, then as shown in Chart C, the volume of carbon dioxide formed would be half the volume of the oxygen originally in the air. The percentage of carbon dioxide in the gases formed would then be, instead of 21 per cent., one-half of 21 per cent. or 10½ per cent.

These relations may also be shown by the charts in Fig. 2. The area of the circles in each case represents the amount of gas going up the chimney for one pound of carbon burned. As it requires a definite amount of oxygen to burn a pound of carbon and a definite amount of carbon dioxide is formed, the volume of carbon dioxide remains the same in each

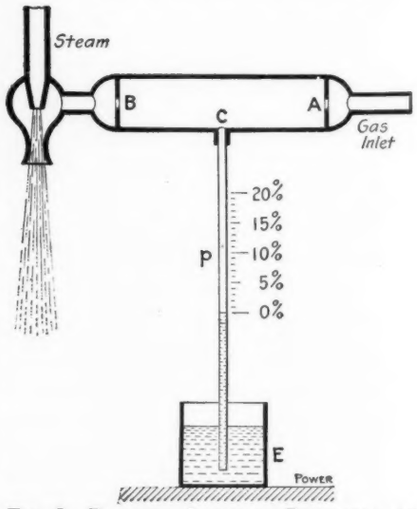


FIG. 6. DIAGRAM SHOWING PRINCIPLE OF UEHLING CO_2 RECORDER

case, shown by the small shaded area. In the case of Chart A, all the oxygen is transformed into carbon dioxide and all the remaining area is nitrogen, the percentage of carbon dioxide in the flue gases being 21 per cent. In Chart B the total volume has increased, the amount of nitrogen being increased and the the amount of oxygen available for burning one pound of carbon increased; the amount of carbon dioxide formed remains the same as in the first case.

Just as the factory manager can look over his books and note the value of his raw materials, the cost of manufacture, the price of the finished product, the profit, the value of the waste product, etc., so can the engineer record, in connection with the plant load, the draft, thickness of fire, kind of labor, coal burned, amount of water used, temperature of the flue gases and percentage of carbon dioxide; and thus be guided in running his steam factory so as to turn out the finished product at the least cost.

Typical records of carbon dioxide and temperature are shown in Figs. 3 and 4, which were obtained from a Uehling combined CO_2 machine and pyrometer, or "waste meter," installed in the Edgewater plant of the Corn Products Refining Company. This waste meter is shown in Fig. 5, where also the recording gages can be seen mounted on the board. The recording gages are simply vacuum-recording gages, and it is because this waste meter measures both carbon dioxide and temperatures by changes in partial vacuum, that it is possible to record by independent gages and indicate by water columns, and also that continuous measurement is obtained.

Referring to the sketch of Fig. 6, the flue gas is drawn through the two apertures *A* and *B* by constant suction produced by a steam aspirator. The suction in chamber *C* will remain constant so long as the same amount of gas passes through both apertures. If, however, part of the gas, that is, the CO_2, be absorbed in the space between the two apertures, the vacuum will increase in proportion to the amount of gas absorbed. All that is necessary then in order to measure the percentage of CO_2 is to connect chamber *C* with an indicating water column, or a light vacuum-recording gage.

The engineer aided by a waste meter of this kind is guided in operating his plant so as to cut down the cost of steam production to the least amount compatible with the cost of coal, character of coal, kind of grates, draft available, kind of boiler, etc.

Progress in Return Tubular Boilers

By William Kavanagh

Showing the improvements that have been made in the settings and fittings of horizontal return tubular boilers during late years.

Improvements in the design of horizontal tubular boilers and settings have been slow as compared with other types. Those improvements that have been made in late years, however, include dispensing with staggered tubes, leaving out the middle vertical row of tubes, placing manholes above and below the tubes, dispensing with the handhole in the rear head, the proper protection of the blowoff pipe against overheating, omitting the steam dome and carrying the boiler on rollers or suspending it from girders.

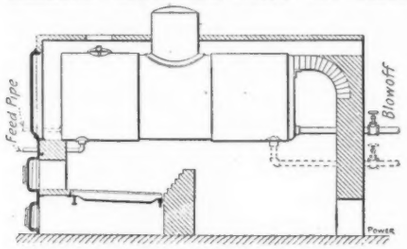


FIG. 1. OLD METHOD OF CONNECTING FEED AND BLOWOFF

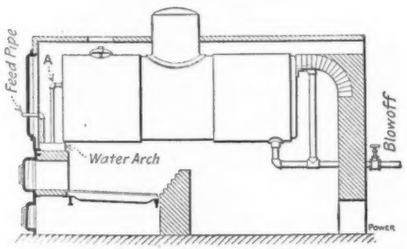


FIG. 2. WATER ARCH AT FRONT AND CONTINUOUS CIRCULATION THROUGH BLOWOFF

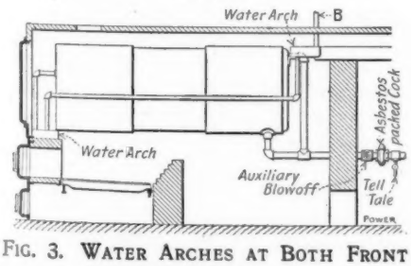


FIG. 3. WATER ARCHES AT BOTH FRONT AND REAR

Fig. 1 represents what may be termed an "old time" setting in which the feed pipe is attached to the bottom sheet, directly over the fire, the object being to heat the feed water before entering the boiler. The blowoff is attached to the rear head some distance above the bottom sheet, which arrangement prevents, to a large extent, the wind and scale from being forced out of the boiler. The dotted lines, Fig. 1, represent the feed introduced through the lower part of the front head; also, the proper connection for the blowoff pipe which is protected by a sleeve or covering of asbestos.

In Fig. 2, the blowoff pipe is protected from overheating by a circulation of water through it. Here, also, the feed is admitted through a water arch, thence through pipe *A* to the boiler at some distance below the water line.

A progressive step toward utilizing waste heat and preventing cracked walls and falling fronts and rear arches, is shown in Fig. 3. Both front and rear water arches are supplied; the feed, entering at *B* and after circulating through the rear arch, which is exposed to the hot gases, passes to the front arch and thence into the boiler where it is discharged through a perforated pipe. The main blowoff pipe, besides being protected by the circulation of water, is fitted with an asbestos-packed cock, an auxiliary blowoff valve and a "tell tale." When the latter indicates leakage, the auxiliary blowoff may be closed and the

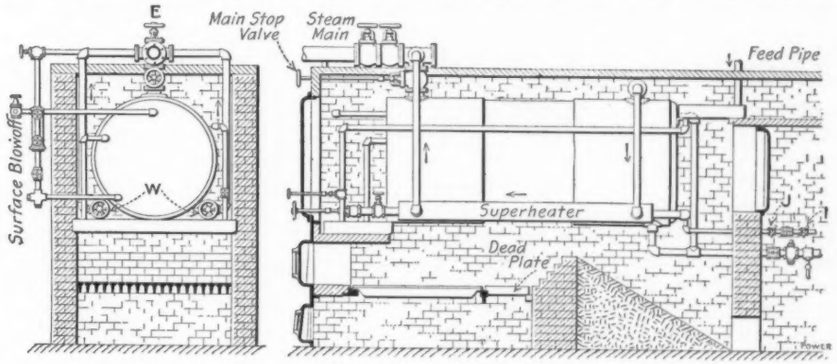


FIG. 4. MODERN SETTING

main blowoff repaired. Previous to the use of auxiliary blowoff valves there was no way of making repairs to the main blowoff cock without shutting down the boiler.

The boiler shown in Fig. 4 embodies the good points gained through many years of experience and represents probably the most uptodate practice with return-tubular boilers. The lugs rest on rollers allowing free longitudinal expansion and contraction of the boiler and both front and rear water arches are fitted. The rear wall has a door permitting inspection and cleaning of the rear head. The steam is taken from the rear of the steam space and passes through a superheater extending the whole length of the boiler, thence to the main header which is also connected directly to the steam space of the boiler. Both an ordinary steam gage and a recording steam gage are fitted.

The furnace is hand fired and at the rear of the grate is a dead plate used for banking and cleaning the fires. The damper shaft is carried on roller bearings which permit a very sensitive regulation of the steam pressure. A surface blowoff is attached at the front of the boiler and an improved arrangement of regular blowoff, similar to that shown in Fig. 3, is fitted at the rear.

The water column is fitted with both a high- and a low-water alarm in addition to self-closing gage-glass valves. Also, the water connection to the column is fitted with a tee and brass plug for use when cleaning the connection.

In raising steam the valves *W W* are first opened to allow a circulation of water through the superheater and after the desired pressure has been reached they are closed and any water in the superheater is blown out at the rear, through the valve *I*. Near this valve is placed a small valve *J*, used to indicate the quality of the steam in the superheater. When this valve shows dry or superheated steam the main valves *E E* are opened, and the boiler is put into service.

The boiler-feed pump should be fitted with a safety valve to prevent excessive pressure on the feed line; also, a bypass allowing the pump to run at practically constant speed, any surplus water being discharged back into the suction line. The check valve on the feed line should be placed between two globe valves, thus permitting repairs at any time.

An essential feature with the foregoing equipment is that all pipes and fittings are extra heavy and the connections allow movement and compensate for expansion and contraction. Furthermore, no expansion joints are used, the connections being so arranged as to screw and unscrew in the direction of the stress.

Determining the Value of Fuel

By R. L. Ellis

It is pointed out that the method of purchasing coal upon either the analysis basis or upon an evaporation basis alone, is inadequate, but a combination of the two has been found to give excellent results.

Discussions upon the subject of fuel have, in general, advocated some particular theory as to the best method of determining the value of the fuel to be purchased, the best method of combustion, or a reduction of the smoke nuisance, etc., rather than a sincere desire to ascertain the facts in the case. There is the man who is bent on the elimination of smoke and who has tried to show that all the profits go up the stack in the form of smoke. As a matter of fact, the visible element in smoke amounts at most to but a very small percentage of the total heat and it is easily possible to have absolutely smokeless combustion and far from economical operation, although from certain standpoints the elimination of smoke is desirable.

There are others who maintain that the B.t.u. in the coal is the proper basis of purchase, attempting to class the whole carload or more from a sample weighing a gram or less. The contract of a certain concern which proposes to purchase coal on B.t.u. specifications, provides for certain penalties for excess of ash, a deviation in the proximate analysis from that specified, an excess of sulphur and for deficiencies in the heat contents. But might not the coal vary rather considerably in each particular and there be no marked difference in the actual results obtained? Also, if these penalties and bonuses apply, how are the amounts to be determined for the variations? Certainly the penalties and bonuses should represent not arbitrary amounts but only real variations in the worth of the coal to the consumer.

Again, there are those who are opposed to the scientific analysis and buying of coal; they contend that the only measure of the value of a coal is the quantity of water it will evaporate per pound. There is a measure of truth in each treatment of the subject, but the solution of the problem lies in a combination of the practical and the scientific methods. It is desirable to eliminate smoke but it is more important to secure economical combustion. It is important to obtain a high percentage of CO_2 in the flue gases but one may get too much for the overall economy. It may be desirable to know the character of coal used and its heat contents, but for the particular furnace conditions in which the fuel is to be used this may not furnish a true guide as to the desirability of the coal. On the other hand, without the analysis one may fail to get the proper results from a really economical coal and discard it as worthless on account of not being able to interpret the facts furnished by the scientific analysis.

The real measure of the value of coal for commercial use is its cost per unit of finished product. The total cost of the coal includes its cost at the mine, cost of delivery, unloading, stoking and handling the ashes, together with any other expense due to the use of the coal. The finished product may be supplying a certain number of square feet of radiation at a given temperature, yards of cloth made, kilowatt-hours, etc.

Coal as usually specified by analysis contains a certain amount of moisture, volatile matter, fixed carbon and ash, with a separate determination of the sulphur, and finally, a certain number of B.t.u. per pound. Usually with the dealer this means a mine sample or a sample taken by cross-cutting the seam and a careful elimination of any dirt above or below the seam, but with the purchaser it should mean an average car sample, which is an entirely different proposition.

Some contracts make deductions for moisture, but unless the coal be weighed at the point of delivery this is manifestly unfair for the reason that the excess moisture may represent water in the form of rain which fell after the coal left the mines. On the other hand, if the coal be shipped in fair weather and remain several days on the road it might be flooded with water at the mine and be practically dry upon delivery, which would afford the seller a very large advantage. Unless the quantity of coal is sufficient to warrant scales at the point of delivery, it is inexpedient to make any provision for correcting for moisture in the coal. About the only thing that can be done is to weigh an occasional car under different weather conditions to ascertain whether the mine owners are attempting to act unfairly in the matter and, if so, it has been the experience of the writer that the sooner

a contract with a concern of such character is broken the better.

In the proximate analysis it is desirable to know if the volatile matter be determined with or without a previous drying-out process; the results may be markedly different in the two cases. Furthermore, it should be known whether the volatile matter is all combustible and whether it distils off quickly or slowly. These affect the adaptability of the coal for a particular furnace unless the furnace be designed to handle economically coals of widely different characteristics, but very few of the commercial forms are so arranged.

At the plant with which the writer is connected, the average cost of coal stoked and the ash removed was $2.76 per ton, and the coal per kilowatt-hour averaged for the year 8.60 pounds. With this information at hand, several carloads of coal were ordered and placed in the bin, samples being taken during unloading. These samples were sealed in quart jars, labeled by car numbers and sent to a chemist for analysis. The coal was then burned under the boilers and data taken as to the evaporation and the kilowatt-hours delivered at the switchboard.

Having done this, the question then arose as to what had actually been accomplished. It was known that a certain amount of coal had been burned per kilowatt-hour at a certain cost per ton of coal fired. But what of it? The results were not of such a character as to determine whether the coal was or was not desirable for the particular conditions. It was known that the coal ran about 8 per cent. in ash, 35 per cent. in volatile and 57 per cent. in fixed carbon, with less than 1 per cent. of sulphur and a heat content of 13,750 B.t.u., but the actual performance of the coal could not be correlated with the results of the analysis, and, furthermore, wide variations were observed from day to day in the actual results with apparently no change in load or weather conditions. Manifestly there were the personal equation of the fireman and other factors to consider.

To this end, a thermometer was placed in the feed-water supply, another in the uptake of the stack, a gas-sampling apparatus in the base of the stack and at several places in the furnace proper; an Orsat apparatus was purchased, the engines were reindicated and the integrating meters on the switchboard recalibrated. A water-weighing apparatus was installed on the feed-water line and the coal scales were overhauled and calibrated. Some more coal was bought and the conditions of the whole plant were studied thoroughly. It was then found that coal from different mines behaved very differently in the boiler, and in order to obtain the cheapest and most economical fuel it would be necessary to design a furnace that would economically handle coal of wide variation in character. This work took quite some time, but finally a furnace was produced that would successfully handle coal varying all the way from coke to the highly volatile coal from the Alabama fields.

It is now the practice at this plant when purchasing coal to take a sample from each car for analysis. In a day or two, after the fireman has become familiar with the coal, results are noted. Of course, records of all conditions are taken daily but the results are expected to be poor with a given coal until the fireman has learned to handle it properly; hence in estimating the value of the coal these experimenting days are eliminated.

After the fireman has become familiar with the coal, frequent readings are taken of the thermometer in the uptake, also frequent determinations of the flue gas, as well as a 12-hour sample. The temperature of the feed water is so nearly constant at 212 degrees Fahrenheit that it is not recorded and only checked occasionally to see that the heater is in good working order. The amount of water fed to the boilers is noted at the end of each 12 hours and corrected for difference in the level of water in the boiler. The coal is also corrected for the amount on the firing floor at the end of each 12 hours. Readings are taken on the integrating wattmeter as are also readings on the indicating meters to ascertain if the load conditions are normal.

Having previously determined the most economical percentage of CO_2 in the flue gases for the particular coal, it is kept as nearly as possible at that point. It has been found unnecessary to make a complete analysis of the flue gases except occasionally, as the furnace efficiency follows very closely the CO_2 content up to a certain point. The density of the smoke is noted, but this is a very minor consideration since there is no smoke ordinance and with practically perfect combustion the smoke is rather negligible.

The uptake temperature indicates the heat loss through the stack; the record of feed water checks the boiler performance as distinguished from the engine and generator performance; and by weighing and examining the unconsumed portion of the coal, its clinkering character is noted; also, it can be ascertained if there is any considerable amount of unconsumed fuel mixed with it.

From the foregoing, it will be seen that the coal tests at this plant are a cross between the rule-of-thumb methods of the so-called practical school and the refinements of the scientific school. The combination might properly be termed the commercial method of testing. To sum up, in determining what coal shall be purchased, the analysis and heat determination as supplied by the seller are gone over and it is ascertained whether the mine owner is willing to guarantee this as an average car-sample analysis. The financial condition of the mine is then looked into, also the railroad facilities for a continuous supply of coal. These factors serve as a general guide as to what may reasonably be expected of the coal. If the ash be low, the B.t.u. contents reasonably high, and the coal from a field that has given good results and the price attractive, several cars will be purchased for trial. It is usually possible to purchase with the price on the sample cars open and to be determined by the results in comparson with the coal then in use; in other words, at so much per kilowatt-hour for coal cost.

In making up an estimate as to the probable value of the coal, the proposed price of the coal plus the freight, the cost of unloading the coal and the cost of handling the ashes for each per cent. of ash in the coal are considered; this total is divided by the number of B.t.u. The result is strictly arbitrary, since the costs are per ton and the B.t.u. are per pound. This figure, however, in comparison with figures previously obtained from other coals gives a fairly accurate predetermination of the probable value of the coal in comparison with others.

At the time of testing the coal commercially, if the results are good, the samples are analyzed and compared with the mine analysis, each other and the actual commercial results. If the results all told show that the fuel is a desirable one a contract is made.

The existing contract is ideal for simplicity and practically gives results that are believed to be equally as good if not better than those obtained by the more involved contracts, and it is manifestly fair to both concerns. It provides that the coal to be furnished shall not differ materially from that sent as a sample in the proportion of volatile matter and fixed carbon; it shall be from the same seam and furnished with regularity at a specified rate. The price is specified. In the particular coal now being purchased the ash from the sample cars did not exceed 8 per cent. and the B.t.u. did not fall below 14,000. It is, therefore, specified that if the ash habitually exceeds 10 per cent. and the B.t.u. falls below 13,500, the purchaser shall have the right to reject the coal and cancel the contract, or a new price shall be agreed upon between the parties to the contract.

In this it will be seen that the actual value of the coal is determined by its use in the plant in which it is to be used, and the conditions are checked to ascertain if the shortcomings of any sample are due to lack of quality or improper handling. The analysis of the coal is only used as a check and to insure the furnishing of coal on the contract of substantially similar character.

Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

A New Interpole Dynamo

The development of heavy electric traction and large factory equipments has created an extensive demand for direct-current dynamos that will work sparklessly under widely and rapidly fluctuating loads and abnormal overloads and for meeting such requirements the interpole construction, now well known, is admirably fitted. The accompanying engravings show the essential features of a machine of this type which has been recently brought out by the Westinghouse Electric and Manufacturing Company for direct mounting on the extension of the prime-mover shaft.

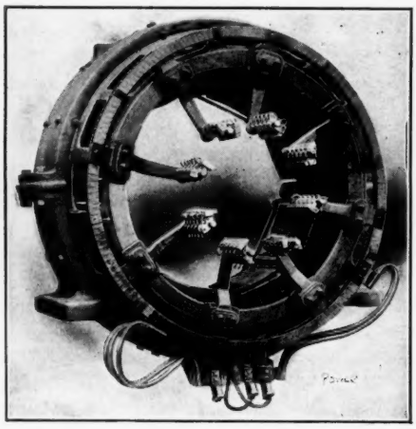


FIG. 1. INTERPOLE FIELD MAGNET

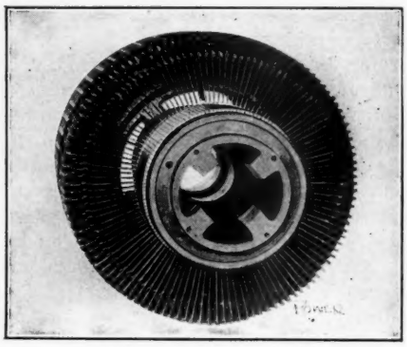


FIG. 4. COMMUTATOR END OF COMPLETE ARMATURE

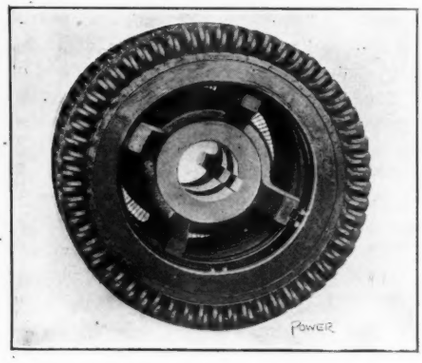


FIG. 5. REAR END OF COMPLETE ARMATURE

FIG. 2. MAGNET POLE

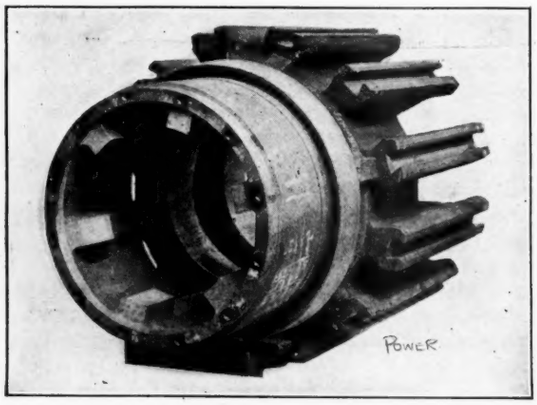


FIG. 3. ARMATURE SPIDER AND COMMUTATOR CORE

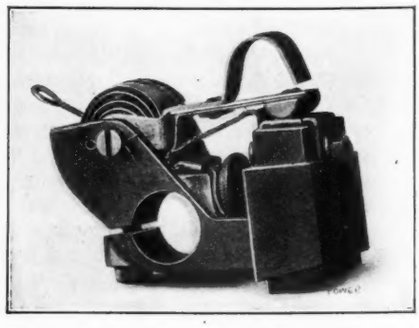


FIG. 6. BRUSH AND HOLDER

The complete field magnet is shown in Fig. 1, from which it will be evident that the brushes are not provided with the means for adjustment which is always found on ordinary generators without interpoles. The brush rigging is set accurately at the factory and the field-magnet yoke and the ring which carries the brush holders are marked so that this position can be duplicated instantly when the machine is erected in its working position. The magnet yoke ring is of cast steel and only a little wider than the magnet poles; consequently, the field-magnet coils extend beyond the yoke edges and their heat is readily radiated. The projecting portions of the coils are protected from mechanical injury by a skeleton framework at each side of the yoke ring and the brush rigging is supported by one of these frames, as shown in Fig. 1.

The main magnet poles are built up of thin steel sheets riveted into a solid mass, as indicated in Fig. 2; these are bolted to the inner face of the yoke ring, which is machined smooth all the way around and across the face. The interpoles are solid steel blocks, also bolted to the yoke ring.

The armature core is built up of annular segments dovetailed to ribs on the central spider and the latter is cast with internal ribs also, instead of being solid down to the shaft. Fig. 3 shows this construction; the barrel projecting toward the observer supports the commutator, forming the drum and one flange of the commutator core. The armature core is provided with spacers at intervals along its length, as usual in large machines, forming ventilating ducts between the adjacent laminations of the core. The core is, of course, slotted to take the coils, which are form-wound and individually insulated. The winding is of the straight-out or barrel type, leaving

the heads of the core open to the surrounding air, as Figs. 4 and 5 show; these views indicate how clean-cut and well ventilated the armature and commutator are.

The brush holders might be characterized as "the usual pocket type," but there are several details which, though relatively minor, deserve special consideration. The "pigtail," for example, which is of flat copper-wire braid, is attached to the frame of the brush holder by means of a large thumbscrew and to the brush by means of a through bolt; moreover, the "pigtail" is so located that it cannot foul the spring or interfere with the movement of the brush, although it is easily accessible for removal. See Fig. 6. The bolt which attaches the "pigtail" to the brush passes through the ends of a ∩-shaped strap which straddles the top end of the brush and affords a seat for the end of the pressure finger; the latter is equipped with a rounded pressure block which touches the brush along a line, no matter what the position of the brush, and therefore does not tend to tilt the brush or jam it against the wall of the pocket. The pressure finger is forced against the brush by a flat spiral spring the tension of which is adjustable by the usual spindle and lever.

These machines are built in sizes ranging from 25 to 1000 kilowatts and of the standard direct-current voltages. They are compounded to give a rise of 7 volts in the low-voltage machines, 20 volts in the middle-voltage machines and 50 volts in the railway machines.

National Electric Light Convention

The thirty-fourth convention of the National Electric Light Association was held this year at the headquarters of that body, the Engineering Societies building, New York. The convention was opened on May 30 with the usual formalities; the delegates were welcomed to the city by acting mayor John Purroy Mitchell, the president of the association delivered his annual address and several important committees presented their reports.

Overhead Line Construction

The report of the committee on overhead-line construction was an admirable piece of work, embracing detailed specifications for materials and methods to be used in building overhead lines for 2300-volt alternating-current distribution and for street-lighting circuits. Because of the completeness of these specifications it is impracticable to abstract or summarize them beyond stating that they cover the dimensions and appearance of chestnut, white-cedar and yellow-pine poles; dimensions and quality of pine, cypress and fir crossarms; sizes and quality of wooden and metal insulator pins, pole-steps and guywires; copper, aluminum and copper-covered steel wires and cables, bare and insulated. Methods of putting up poles and stringing wires are also described and illustrated. The report is really an encyclopedia of modern line construction and worthy of a substantial binding to withstand the constant reference which it justifies.

Meters

The report of the meter committee, presented at the afternoon session of the first day's proceedings, contained some excellent material on the practical care of meters which will be published very fully in an early number of Power.

Grounding Low-tension Circuits

In a paper of the above title, Paul M. Lincoln pointed out the advisability of grounding low-tension alternating-current circuits for protection to life and explained how and why breakdowns frequently occur between the high-tension and low-tension windings of transformers.

The fundamental reason why breakdowns of this sort occur simultaneously with disturbances on the high-tension system, he said, is that transformers act to a considerable extent as condensers because of the interleafing of the sections of the winding; that is, the high-tension "pancakes" act as one set of condenser plates and the low-tension sections as the other. Under such conditions, an alternating difference of potential between the high-tension system and the ground will induce a corresponding difference of potential between the low-tension system and ground.

The amount of potential difference between the low-tension winding and the

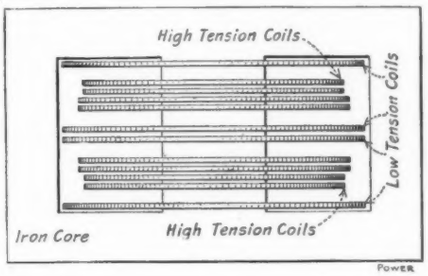


Fig. 1. Sandwiched Transformer Coils

ground will depend on the relative static capacity between the two windings and between the low-tension winding and ground; also, on the average departure from ground potential by the high-tension windings. In a transformer of the shell type with coils arranged as indicated in Fig. 1, the condenser capacity between the low-tension windings and the ground was three times the capacity between the two windings. When the external circuit connected to the low-tension windings also has capacity with respect to the ground, this modifies the danger of breakdown; the maximum danger exists, therefore, when the low-tension windings are entirely disconnected from the external circuit.

The remedy, or preventive, for the evil under discussion is to ground the low-tension windings of the transformers and thereby give the induced static potential an easy and harmless path instead of giving it a chance to break down the insulation. Increasing the insulation of the low-tension windings does no good; it merely increases the relation between the primary-secondary capacity and the capacity between the low-tension windings and the ground, the increase being such as to increase the dangerous static potential between the low-tension windings and the ground.

Improvements in Single Phase Motors

Under this title, W. A. Layman presented an interesting analytical description of a type of self-starting single-phase motor which the Wagner Company is developing under the patents of Val. A. Fynn. The rotor contains two distinct windings, one a simple squirrel cage and the other a polar winding, in the same slots. The polar winding is connected, through a commutator and brushes, in series with the stator winding and serves to produce the torque necessary for starting; at normal speed an automatic switch connects its brushes to an auxiliary stator winding which "compensates" the inductive effect of the main winding and raises the power factor of the machine. The construction and principle of operation will be described in this department in the near future.

Relation of Load to Power Station Equipment

F. D. Newbury presented a paper dealing with the effect of the character of the load upon the equipment of a generating station and with the adaptation of the station equipment to meet the requirements of the kind of load with which the present day station has to deal.

In the alternating-current system the characteristic that has led to more trouble in the generating equipment than any other one thing is the effect of low power factor. A simple way of considering this question is to assume that the actual load can be divided into two components, one equivalent to the energy load and the

other equivalent to the combined leading and lagging wattless load.

The wattless component of the load may be a demagnetizing component, such as required by induction motors and inductive loads in general; or it may be a magnetizing component supplied by overexcited synchronous motors or static condensers.

A distinction should be made between raising the power factor by increasing the energy load and by decreasing the wattless load. While the former is desirable the latter is more desirable, since a low power factor is a positive detriment only when the load is a maximum and station capacity is at a premium, while a decrease in the wattless load is always of advantage, since it means an increase in operating efficiency.

Practically all loads supplied by central stations have a demagnetizing component. Power factors above 95 per cent. are obtainable only when the load consists of synchronous motors or rotary converters. Power factors of 90 to 95 per cent. can be expected only when the load is entirely noninductive or when synchronous motors are supplied together with a relatively small proportion of inductive apparatus. For the average central station carrying a lighting and power load, 80 per cent. power factor should be assumed [in considering the station equipment]. For a plant to supply a large proportion of induction motors, arc lamps and other inductive apparatus, 70 per cent. is a fair estimate.

It is necessary to estimate the power factor of the load in order to choose the relative rating of the generators and engines intelligently, because the engine rating should correspond to the generator ability in true power at the power factor that will be imposed by the load.

When it is a question of adding new load to an existing station the probable power factor of the load may be estimated as follows:

Kind of Load	Probable Power Factor
Incandescent lighting with small transformers.	From 90 to 95 per cent.
Alternating-current inclosed arc lamps with constant-current transformers.	From 60 to 75 per cent., depending upon the proportion of full load on transformers. An average figure would be 70 per cent.
Direct-current metallic arc lamps with rectifiers.	From 55 to 70 per cent., depending upon load on rectifiers. An average figure would be 65 per cent.
Single-phase induction motors; squirrel-cage rotors, $\frac{1}{10}$ to 1 horsepower.	From 55 to 75 per cent.; average 68 per cent., at rated load.
Single-phase induction motors; squirrel-cage rotors, 1 to 10 horsepower.	From 75 to 86 per cent.; average 82 per cent., at rated load.
Polyphase induction motors; squirrel-cage, 1 to 10 horsepower.	From 75 to 91 per cent.; average 85 per cent., at rated load.
Polyphase induction motors; squirrel-cage, 10 to 50 horsepower.	From 85 to 92 per cent.; average 89 per cent., at rated load.
Polyphase induction motors; phase-wound rotors, 5 to 20 horsepower.	From 80 to 89 per cent.; average 86 per cent., at rated load.
Polyphase induction motors; phase-wound rotors, 20 to 100 horsepower.	From 82 to 90 per cent.; average 87 per cent., at rated load.
Rotary converters, compound wound.	At full load the power factor can be adjusted to practically 100 per cent. At light loads it will be lagging, and at overloads slightly leading.
Rotary converters, shunt wound.	The power factor can be adjusted to any desired value, and will be fairly constant at all loads with the same field rheostat adjustment. Rotary converters, however, should not be operated below 95 per cent. power factor leading, or lagging, at full load or overload.
Small heating apparatus.	The power factor of the load is practically unity, but the distributing transformers will lower it to some extent.
Arc furnaces.	From 80 to 90 per cent.
Induction furnaces.	From 60 to 70 per cent.
Welding transformers.	From 50 to 70 per cent.
Synchronous motors.	Adjustment between practically zero power factor leading, to zero power factor lagging.

From the foregoing table it is evident that the only kind of load which affords any control over power factor is the synchronous motor. This fact has led to an increasing use of synchronous motors by central stations in order to improve the power factor of the system. Unfortunately, the complication of a separate exciting source and the ability to start only under a comparatively small load restricts the use of synchronous motors largely to location at the station, where skilled attendance is at hand, or to motor-generator sets.

Synchronous motors have been operated without load to improve the power factors of systems but it is more economical to utilize the motors to do mechanical work at the same time. The required capacity of such a motor is the vector sum of the required wattless and energy inputs; that is, the total input in kilovolt-amperes is equal to the square root of the sum of the squares of the wattless kilovolt-amperes and the kilowatts. For example, if the wattless intake from the line be 600 kilovolt-amperes and the energy intake, converted into mechanical work, be 800 kilowatts, the total intake will be 1000 kilovolt-amperes.

To determine the proper size of synchronous motor to use for effecting a given improvement in station power factor and to do some mechanical work also, it is necessary to consider the characteristics and size of the station load. To the existing station load must be added the true kilowatts that the motor will require to do the mechanical work and supply its own losses. From the *desired* power factor and the total load in kilowatts the total kilovolt-amperes and the future wattless kilovolt-amperes are obtained and subtracting these from the existing wattless kilovolt-amperes gives the wattless component to be supplied by [to] the motor.

For example, with a load of 1200 kilowatts and a power factor of 70 per cent., the wattless kilovolt-amperes will be 1220 [1224 is the theoretically accurate figure.—Ed.]. If the synchronous motor is to do work (including its losses) requiring 240 kilowatts intake, the future energy load will be 1440 kilowatts. If a power factor of 90 per cent. is to be obtained, the future wattless kilovolt-amperes will be 698 and the difference between 1220 and 698 being 522, that is the number of wattless kilovolt-amperes for the motor to take. The total intake of the motor, then, must be

$$\sqrt{240^2 + 522^2} = 575$$

kilovolt-amperes. In general, it will not be found worth while to raise a station power factor above 90 per cent., since the investment necessary is seldom warranted by the improvement in operation.

Power Required by Industrial Machinery

The report of the committee on power should be of immense value to central power stations. It contains an extensive list of industries which are operated by electricity from central stations in various cities widely distributed about the country, in which the kind of machinery, type of drive, service hours per week and kilowatt-hours of actual service per year are stated; also, an astonishingly full list of motor ratings for industrial machines of all kinds and sizes, from a $\frac{1}{8}$-horsepower pamphlet stitcher up to a 250-horsepower stone crusher. In between are printing presses, wood-working machines, cement machinery, boiler-shop machines, textile machinery, laundry equipment, etc.

Ventilation of Turbine-driven Generators

A paper on this subject was read by R. B. Williamson. The author pointed out that alternators driven by steam turbines are very small for their output, because of their high speed, and that therefore the problem of getting rid of the heat developed in the windings is a difficult one. Forced air circulation is the means commonly applied in this country. The generator is completely inclosed and the air is conveyed through passages to the parts where heat is evolved.

Theoretically, the cubic feet of air required to be passed through the machine per minute for each kilowatt of loss in the machine would be equal to 1650 divided by the temperature rise in Centigrade degrees, but as all of the air is not uniformly heated and the heat-developing parts of the machine are hotter than the discharged air, a larger amount is necessary. For the usual limit of temperature rise, cooling air should be supplied at a rate of from 100 to 150 cubic feet per minute for each kilowatt of internal losses; 125 is a fair average figure.

The total internal loss will usually be from 4 to 6 per cent. of the rated kilovolt-ampere output, being larger for the

smaller machines. As a rough estimate, therefore, the allowance of cooling air may be taken as 5 to 7½ cubic feet per minute per kilovolt-ampere of rated output. In some cases from 4 to 6 cubic feet per kilovolt-ampere will be sufficient, but the larger allowance is preferable, especially if the turbine has to operate in a hot locality.

In order to handle such large quantities of air, careful attention must be paid to the pipes through which it is supplied and the air should be as clean and cool as practicable. In some cases it may be drawn directly from the basement, but this should not be done if the space below the generator is occupied by auxiliaries which heat the air. Good results have been obtained by partitioning off the generator end of the basement so that the heat from the auxiliaries will be confined to the steam end.

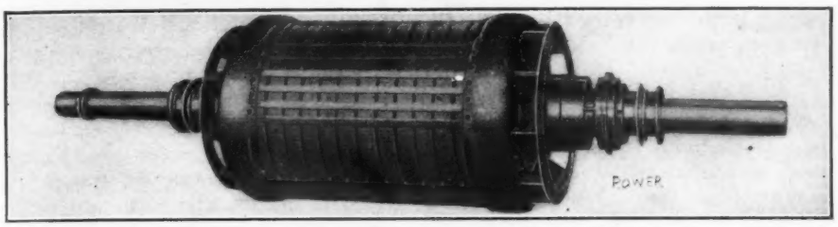


FIG. 2. CIRCULATING FANS ATTACHED TO FIELD MAGNET

In case cool air cannot be obtained from the basement, a pipe or duct should be run outdoors and the opening protected so that rain or dirt cannot be drawn in. Ducts should be as straight as possible and of such cross-section that the air velocity will not exceed 1000 to 1200 feet per minute. When air is drawn from outdoors, it is advisable to have dampers arranged so that it can, if necessary, be taken from the basement in cold winter weather.

It is important that the air be clean. The quantity of air passed through these generators is so large that even a small percentage of dust soon results in a large amount of dirt within the machine. Cheese-cloth filtering screens over the intake or in a box in the air duct are a good means of keeping out dust. These must be easily removable so that they can be frequently cleaned without requiring too much time and effort.

A number of methods of forcing the air through the generator have been tried but the most common one is to drive a centrifugal fan at each end of the rotor, the fans being built on the rotor spider, as shown in Fig. 2.

The air discharged by the fans must be passed through the machine with great rapidity and in such manner that all parts will be reached and the heat carried off. This is not easy, because air friction is by no means negligible in its heating effect and any attempt to force large quantities of air through long restricted passages will lead to unsatisfactory results.

The greatest loss is in air friction and core loss; hence the greater part of the cooling air is required for the stator. The loss in the rotor is comparatively small, and in high-speed machines little can be done in the way of ventilating the rotor core by means of air ducts. In fact, in generators running at 3600 revolutions per minute, the rotor core is usually a solid forging without ducts of any kind. However, if the heat developed in the rotor windings is passed into the surrounding mass of metal, it is rapidly conducted to the outer surface and is thence carried off by the scrubbing action of the air.

Fig. 3 illustrates diagrammatically a method of ventilating that has been extensively used and is satisfactory for machines of moderate output. For large high-speed generators, however, the arrangement illustrated in Figs. 4 and 5 gives better results. With the arrangement indicated in Fig. 3 the air passes in two streams through the machine, one stream on each side of the shaft, and if the generator is of large diameter the air becomes heated before it reaches the upper parts; those parts, therefore, are inadequately cooled.

The arrangement shown in Fig. 4 is such that the air is divided into several streams, entering the core ducts through directive passages *A A*, and emerging into the outlet chambers through the passages *B B*. These passages *A* and *B* alternate all the way around the circumference; they are not arranged in two groups at the top and bottom of the structure, as the longitudinal section would seem to indicate. The final discharge can be taken out at the top, bottom or side of the housing. The stator shown in Fig. 5 is provided with this arrangement; an air intake is provided on each side of the bottom of the housing and the outlet is at the top.

This multipath method of ventilation for large machines has a number of advantages. One-half of the outside circumference of the stator punchings is exposed directly to air from the fans and the stator is not dependent for its cooling on hot air that has already passed over the rotor before reaching it. The use of a number of short paths in parallel through the core greatly reduces the resistance offered to the flow of air; for a given pressure, therefore, a much larger quantity of air will pass through the machine. The air, from the time

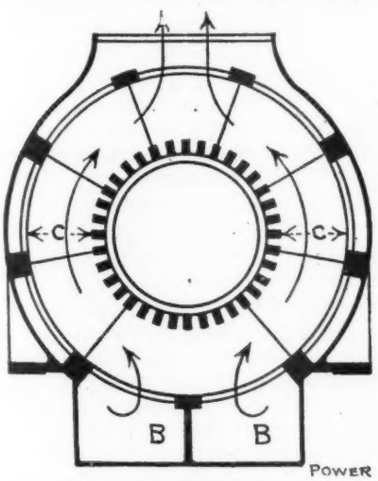


FIG. 3. AIR CIRCULATION IN SMALL MACHINES

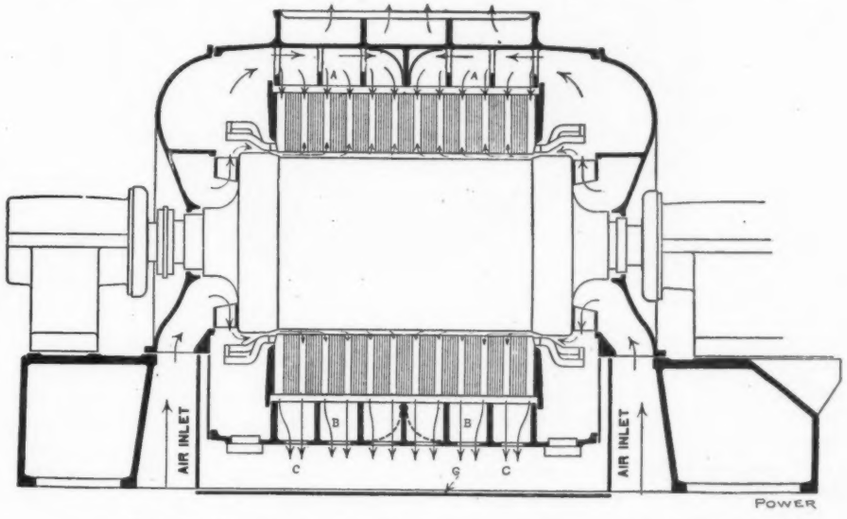


FIG. 4. MULTIPATH AIR CIRCULATION THROUGH GENERATOR

it enters until it leaves the machine, does not have to pass through a long path and, being divided into a number of parallel streams, the velocity in the ducts is very moderate compared with that in the two-path arrangement. The whole mass of iron directly behind the teeth and coils is maintained at a low temperature and any slight inequalities in temperature are equalized by the ready flow of heat in the plane of the laminations. Extensive tests made with this arrangement show that machines of large output can be cooled very evenly.

Prime Movers

The committee on prime movers presented an extensive report which contained a good deal of important information. As the committee had no new types of prime mover to investigate, it confined its attention to the performance of existing types in the stations of the member companies, or such of them as could be prevailed upon to supply the desired information.

No troubles which would seriously affect continuity of service have been reported in steam power plants. A number of minor defects have been mentioned which are discussed in the report, but it would seem that insofar as steam turbines are concerned this type of apparatus is rapidly reaching a standard which leaves very little room for criticism in the way of economy of operation or reliability of service. The auxiliaries, however, were the subject of some criticism from the operating companies, and these criticisms were referred by the committee to the makers of the various machines, who either announced changes in design to correct the troubles or offered to make such changes as were necessary in the machines. An abstract of the report on steam turbines will be printed next week.

Very little new development has been found in gas-power apparatus, and like steam power the general tendency has been toward the perfection of the apparatus. A detailed report on that subject, prepared chiefly by J. B. Klumpp, of the committee, formed a part of the general reports; this special discussion will be printed in abstract in the Gas Power Department next week.

Protection from Lightning

In its annual report, the committee on protection from lightning stated that those transmission lines having overhead ground wires seem to suffer the least damage; in fact, one operator reports that the troubles from broken insulators, shattered poles, burned-off wires and crossarms on lines protected in this manner are less than 20 per cent. of those on the lines without this type of protection. Similar results are reported in a great many other cases, and, in fact, the importance and value of the overhead ground wire is now so firmly established by experience that in almost every case where new lines are constructed provision is made for it.

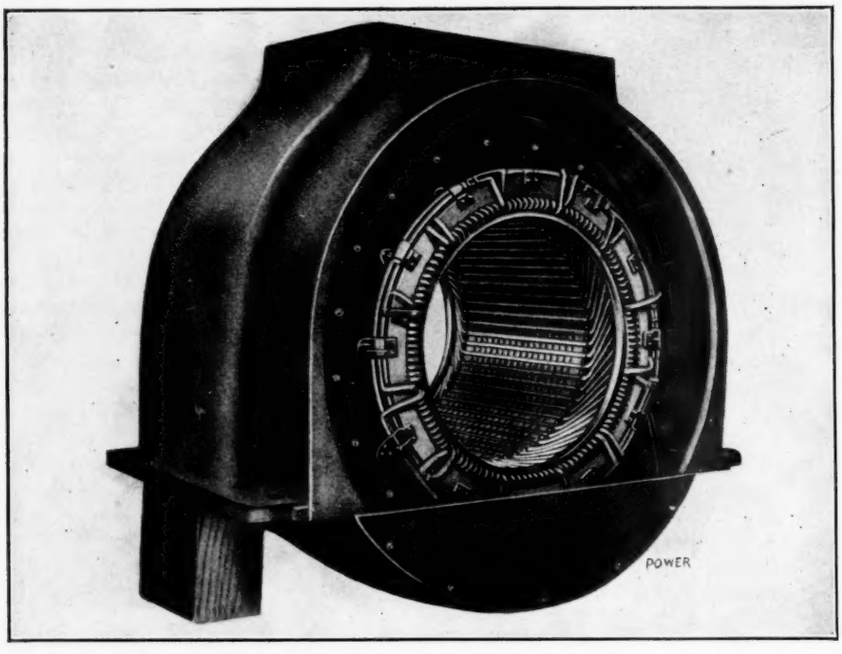


Fig. 5. Stator Equipped for Multipath Air Circulation

In some particular cases, where an unusual amount of trouble was experienced from insulators spilling over, special devices have been developed as an alternative of the overhead ground wire. One of these devices is in the form of a grounded metal ring for each insulator. These are reported as being effective, though the use of them has not eliminated all line disturbances and is no protection against the direct stroke. In some other cases a grounded spark gap has been provided for each insulator; still another form is that of installing a grounded wire on each pole and carrying this wire well above the top of the pole. Some of these devices are used in connection with and others without the overhead ground wire, so there are few definite data at hand on which to base judgment as to their relative value. These experiments are reported as being more or less successful, and especially to the end of reducing the interruptions to the service, but it is still a question if the expense of installation will be justified in all cases.

In some few instances attempts have been made to protect the transmission lines by the installation of arresters at points far removed from the stations, but in most cases these experiments have resulted in failure. The tendency of the older type of arresters to arc over and short-circuit the line and the frequent inspection and care required for the electrolytic type reduce their usefulness to a minimum for use at remote points.

A special device known as the arcing-ground suppressor is now being experimented with for the relief of transmission-line troubles, due to an arc around the insulator. This device is designed to be used at the busbars of the principal station, to take care of the entire system. The arcing-ground suppressor consists essentially of an electrostatic and electromagnetic selective relay. This selective device picks out the faulty phase and closes the release circuit of a single-pole oil switch which is connected between the faulty phase and ground. The oil switch shunts out the accidental arc at the insulator and opens up again immediately. If the insulator is properly designed, the arc will invariably take place around the porcelain skirts, and, therefore, the arcing-ground suppressor will entirely eliminate the trouble. If the insulator should be punctured, the switch of the arcing-ground suppressor is again automatically closed and thereby prevents the high-frequency oscillations in the circuit which would otherwise result, due to the make-and-break of the arc at the faulty insulator.

The committee recommended that where lines are operated separately each line should be provided with a lightning arrester, installed beyond all station apparatus; where several lines are invariably supplied from common busbars, a lightning arrester at each busbar is sufficient. In addition to lightning arresters, the committee recommended the use of choke coils on every circuit leaving a generating station. For stations to be equipped newly with lightning arresters, the committee favors the electrolytic type; also for stations where other types of arrester have not afforded satisfactory

protection, if investigation shows that the arresters have been properly installed and maintained.

Lightning arresters on distribution systems do not usually protect any apparatus that is appreciably more than 500 feet distant. On four of the larger systems, where arresters are installed an average of 2000 or 3000 feet apart, the minimum distance being about 1000 feet, the losses of arresters vary from 0.07 per cent. to 0.7 per cent. of those installed, while in other places, where the spacing is about one mile, the losses run as high as 3 per cent. of the arresters installed.

Election of Officers

The annual election of officers held on the final working day of the convention resulted as follows:

John F. Gilchrist, of Chicago, president; Frank M. Tait, of Dayton, Ohio, first vice-president; Arthur S. Huey, of Oklahoma, second vice-president; T. C. Martin, of New York, secretary; George H. Harries, of Washington, D. C., treasurer.

Conduit Wiring Data

By O. B. Arland

Although the National Board of Fire Underwriters and various municipal inspection bureaus have established extensive rules thoroughly covering the quality and thickness of the rubber insulation, as well as the strength of braiding, for interior light and power conductors installed in unlined metal conduits, as a rule, they leave the proper size of such conduits to the judgment of the individual engineer or contractor.

This is an important matter and one that is not always sufficiently appreciated, with the frequent result that, through ignorance or unwise economy, a conduit of too small an internal diameter is used, causing injury to the conductors and their insulation by reason of excessive friction on the covering and tensile stresses imposed upon the conductor while being hauled into such a conduit.

A table of conduit wiring data based on an experience and observation of several years was worked out by the writer in 1900 for his personal use and has since been successfully used by several contractors and construction men.

This table has been revised this year and is based on the present requirements of the National Board of Fire Underwriters for interior low-potential wiring for voltages up to 600. It is reproduced here in convenient form for use.

The wire diameter and conduit sizes below the first six horizontal rows are restricted to stranded conductors because it is not good practice in conduit work to use solid conductors for sizes larger than No. 8 Brown & Sharpe gage.

Although no conductor smaller than No. 14 is permitted by the fire underwriters for this class of work, two smaller sizes are given because they are frequently used in signaling systems.

The carrying capacities of wires with weatherproof insulation are given in the fourth column of the table for convenience in other work. This kind of insulation is not permitted in conduit work.

The diameters specified in the fifth column in thirty-seconds of an inch are the over-all measurements, outside of the finishing braid.

CONDUIT WIRING DATA

Size B. & S. Gage	Size Circular Mills	Amperes Rubber Insulated	Amperes Weather Proof	Diam. Rubb. Insul. Double Braid, in 32ds Inch	Size of Conduit—unlined. For Wires Rubber Insulated and Double Braided. Permissible Number of Wires in One Conduit: 1	2	3	4	5	6	7	8	9	10	11 12	13 14	15 16	17 18	19	20 21
Solid 18	1,624	3	5	6	¾	¾	¾	¾	¾	¾	¾	¾	¾	¾	1	1	1¼	1¼	1¼	1¼
16	2,583	6	8	7	¾	¾	¾	¾	¾	1	1	1	1	1	1	1¼	1¼	1¼	1¼	1¼
14	4,107	12	16	8	¾	¾	¾	1	1	1	1	1	1¼	1¼	1¼	1¼	1½	1½	1½	2
12	6,530	17	23	9	¾	¾	¾	¾	1	1	1¼	1¼	1¼	1¼	1¼	1½	2	2	2	2
10	10,380	24	32	10	1	1	1¼	1¼	1¼	1¼	1¼	1½	1½	1½	1½	2	2	2	2	2
8	16,510	33	46	11	1	1¼	1¼	1¼	1½	1½	1½	2	2	2	2	2	2	2½	2½	
Stranded 6	26,250	46	65	14	1	1¼	1½	1½	1½	1½	1½	2	2	2	2½	3	3	3		
5	33,100	54	77	15	1¼	1¼	1½	1½	2	2	2	2	2½	2½	3	3	3	3		
4	41,740	65	92	16	1¼	1¼	1½	1½	2	2	2	2	2½	2½	3	3	3	3½		
3	52,630	76	110	17	1¼	1½	1½	2	2	2	2	2½	2½	3	3	3	3½	3½		
2	66,370	90	131	19	1½	1½	2	2	2	2½	2½	2½	3	3	3	3½	4	4		
1	83,690	107	156	21	1	1½	2	2	2½	2½	3	3	3	3	3½	3½	4	4½		
0	105,500	127	185	23	1	2	2	2	2½	3	3	3	3½	3½	3½	4	4½	5		
00	133,100	150	220	24	1	2	2	2½	2½	3	3	3	3½	3½	4	4	4½	5		
000	167,800	177	262	26	1½	2	2	2½	3	3	3½	3½	3½	4	4	4½	5	5		
0000	211,600	210	312	28	1½	2	2½	3	3	3½	3½	3½	4	4	4½	5	5	6		
	250,000	235	350	30	1½	2½	2½	3	3½	3½	4	4	4½	4½	5	5	6	6		
	300,000	270	400	32	1½	2½	3	3	3½	4	4	4½	4½	5	5	6	6			
	350,000	300	450	1″ 2	1½	3	3	3½	3½	4	4½	4½	5	5	6	6	6			
	400,000	330	500	1″ 3	1½	3	3	3½	4	4½	4½	5	5	5	6	6				
	450,000	360	545	1″ 5	1½	3	3	3½	4	4½	4½	5	5	6	6	6				
	500,000	390	590	1″ 6	1½	3	3½	3½	4	4½	5	5	6	6	6					
	550,000	420	635	1″ 8	2	3	3½	4	4½	5	5	6	6	6						
	600,000	450	680	1″ 9	2	3½	3½	4	4½	5	5	6	6	6						
	650,000	475	720	1″ 11	2	3½	3½	4	4½	5	6	6	6	6						
	700,000	500	760	1″ 12	2	3½	4	4½	5	6	6	6	6							
	750,000	525	800	1″ 13	2	3½	4	4½	5	6	6	6								
	800,000	550	840	1″ 14	2	3½	4	4½	5	6	6	6								
	850,000	575	880	1″ 15	2	3½	4	4½	5	6	6	6								
	900,000	600	920	1″ 16	2	4	4	4½	5	6	6	6								
	950,000	625	960	1″ 17	2	4	4½	5	6	6	6									
	1,000,000	650	1,000	1″ 18	2½	4	4½	5	6	6										
	1,100,000	690	1,080	1″ 20	2½	4	4½	5	6	6										
	1,200,000	730	1,150	1″ 22	2½	4½	5	5	6											
	1,300,000	770	1,220	1″ 24	2½	4½	5	6	6											
	1,400,000	810	1,290	1″ 25	2½	4½	5	6	6											
	1,500,000	850	1,360	1″ 27	2½	4½	5	6												
	1,600,000	890	1,430	1″ 28	3	5	5	6												
	1,700,000	930	1,490	1″ 30	3	5	6	6												
	1,800,000	970	1,550	1″ 31	3	5	6	6												
	1,900,000	1,010	1,610	2″ 1	3	5	6	6												
	2,000,000	1,050	1,670	2″ 2	3	6	6													

Table of Conduit Sizes for No. 14 B. & S. Duplex, Double Braided Cables for 0 to 600 Volts

Internal Diameter of Conduit	No. of Duplex Cables Ordinary Runs
½	1
¾	2
1	3
1¼	6
1½	8
2	15

The succeeding columns give the safe internal diameters of conduits to be used for all ordinary construction in buildings of any description where the total number of 90 degrees turns in one line of conduit does not exceed four. Where special conditions necessitate a lead armor over the rubber insulation, slightly larger conduits must be used.

Ordinarily, the fire underwriters do not allow more than four two-wire circuits or three three-wire circuits in one conduit, but it frequently becomes desirable under special conditions to install a larger number of circuits in a common conduit; the required conduit sizes are therefore given up to 21 conductors. The conduit diameters are carried up to 6 inches, although, as a rule, conduits of 4 inches internal diameter are the limit of ordinary practice; 3½-inch conduits are also given, but these are permitted only under special conditions.

A supplementary table is added in the lower right-hand corner, showing how many circuits consisting of No. 14 B. & S. gage duplex cables can safely be put into one conduit.

The conduit sizes in the main table, as will be observed, are calculated on the assumption that the various conductors will be all of the same size. If, therefore, in laying out a conduit for a three-wire system having a neutral of double the capacity of each of the two outside wires, the proper internal diameter of the conduit will be found by using the conduit required for four wires of the size of the main wires of the system. For instance, the conduit for a three-wire feeder of two No. 0000 outers and one 550,000-circ. mil neutral should be sufficiently large to contain four No. 0000 cables, or 3 inches in diameter.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Taking Gas Samples with an Aspirator

By J. C. Parmely

An aspirator may be used to good advantage at times around a gas-producer plant; I once found it very convenient, for example, in making a test of a suction producer and engine. In this test it was desired to operate a Junkers calorimeter to determine the heat value of the gas made by the producer. The usual method of taking samples of gas by the use of aspirator bottles could not be employed in this case because a continuous sample was required and because, in addition to taking the sample from the suction main, where it was at a pressure less than that of the atmosphere by about two inches of water, a pressure of nearly 0.3 of an inch of water was required to force the sample through the meter and other parts of the calorimeter outfit. It was decided, therefore, to use an aspirator to take the sample from the main.

As the aspirator operates upon the principle of the injector, the gas it draws from the main passing from it with the water, it was necessary to provide a chamber in which the gas could separate from the water and where the pressure necessary to force it through the calorimeter apparatus could be applied. This was easily provided by the use of a few pipe fittings, as shown in Fig. 1. A piece of 6-inch pipe *A* was cut about 8 inches long and threaded on both ends, which were capped, as shown; a hole was drilled and tapped in the side about two inches from the bottom, into which a long nipple of ½-inch pipe was screwed; an angle valve *B* was put on its outer end and into the upper outlet of the valve was screwed a ½-inch nipple long enough to reach about half-way up the 6-inch "barrel." Just below the upper cap another hole was drilled and tapped in the side of the chamber to take a ⅛-inch nipple *D*, which provided a connection for the removal of the gas from the chamber. A hole was drilled and tapped in the center of the top cap and a plug was fitted in this hole, the plug affording sufficient metal to take the aspirator outlet in one end and a ½-inch pipe in the other. This pipe reached nearly to the bottom of the separator chamber and provided a water seal which would prevent the leakage of air into the gas main in case the water supply for the aspirator should fail.

The arrangement was connected up as shown in Fig. 2 and its operation was essentially as follows: The aspirator, operating like an injector, drew the sample of gas from the main and this gas passed into the chamber *A* mixed with the water. In the chamber the gas separated from the water, rose to the top of the chamber and passed out through the ⅛-inch connection *D* to the calorimeter. By throttling the water outlet of the chamber at the valve *B*, pressure was applied to the gas to force it through the calorimeter. The apparatus was tried by connecting U-tubes containing mercury to both the suction *E* of the aspirator and the outlet *D* of the separator. By adjusting the valve *C* the suction pressure shown by the column attached at *E* could be varied within the necessary limits and the pressure at *D* could be varied by adjustment of the valve *B*. When the tube *E* was left open, the pressure at *D* could be maintained, as before, and the air taken in through *E* escaped in the form of bubbles in the water.

Having constructed the apparatus and being convinced that it would operate

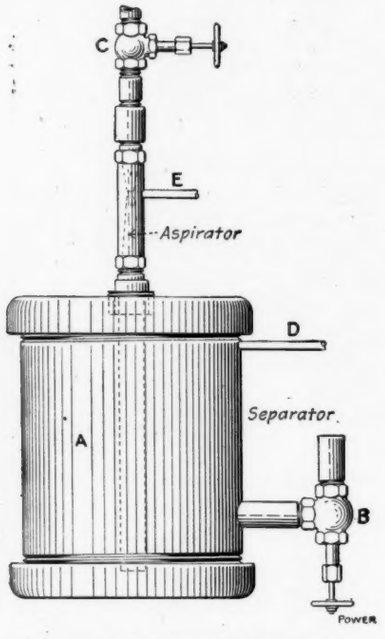


Fig. 1. Aspirator and Separator

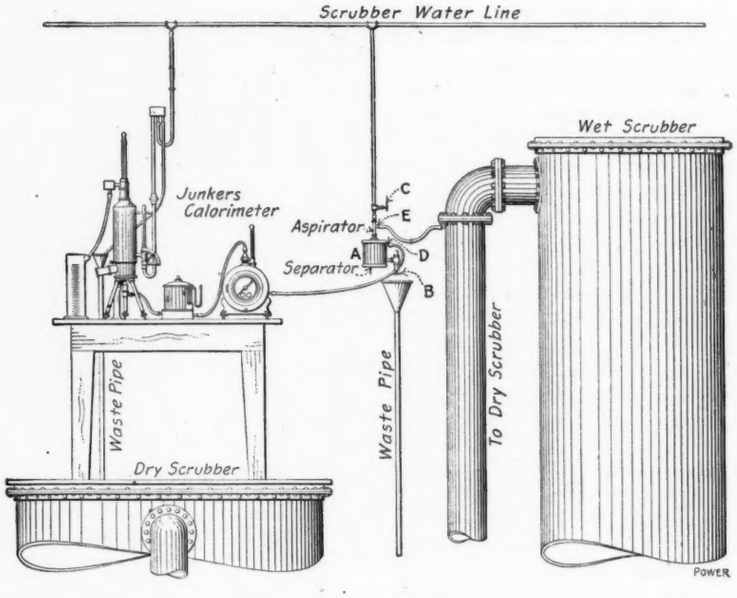


Fig. 2. Complete Equipment for Continuous Gas Sampling

successfully, the next task was to install it at the plant to be tested in a place where it would be readily accessible, be safe from damage and not interfere with the operation of the plant. As shown in Fig. 2, the wet and dry scrubbers were located side by side and it was decided to place the apparatus on the top of the dry scrubber and take the sample from the main connecting the two scrubbers. It was found to be necessary to provide a platform across the top of the scrubber so that the vibrations of the top of the scrubber due to the varying pressure within it would not affect the apparatus. As shown in the sketch, tees were inserted in the scrubber water line and the aspirator and separator were suspended temporarily by the pipe connecting them to this line. A sampling tube similar to that used with a steam calorimeter was inserted in the main and rubber tubing was used to make all connections. One-inch pipes carrying funnels in their open ends were used to carry away the water from the sampling apparatus and the calorimeter.

Due to the fact that the water used in this plant was supplied from a tank upon the roof of the building, the head upon the apparatus did not exceed 15 feet at any time during the tests and this was only sufficient to give a pressure of about two-tenths of an inch of water upon the gas at the meter, which was somewhat below that desired; but it was sufficient to operate the calorimeter successfully, though slowly. With the exception of one stop due to the clogging of the burner, the calorimeter was operated satisfactorily throughout three 24-hour tests.

Oil Engines for Ships

At the spring meeting in London of the Institution of Naval Architects, J. T. Milton contributed a paper on "Diesel Engines for Sea-going Vessels," in which he maintained that, apart from the relative cost and facilities for obtaining supplies of oil fuel and coal, an internal-combustion engine using oil possesses advantages for marine work over one using gas made from coal. The comparatively bulky gas producers and scrubbers are not required; there is no trouble with dust in the cylinders and there should be none with tar on the valve faces. Compared with coal, weight for weight, oil has at least 50 per cent. more heat value, occupies less space, can be carried in double bottoms and other spaces unsuitable for coal and cargo, requires no "trimming" and lessens the number of stokers. Moreover, it is more easily loaded and without the dust and labor of coaling.

In the employment of the Diesel engine the developed horsepower has to overcome the friction of the mechanism, to work the fuel pump and to compress the air necessary for injecting the fuel; in the two-stroke cycle engine it has also to work the scavenging pump. These, Mr. Milton points out, take up more of the gross power than do the accessories of a steam engine; consequently, a less proportion of the indicated power is transmitted to the shaft. For this reason, the power of a Diesel engine is more usually expressed in terms of brake horsepower. On the basis of 0.4 pound of oil consumed per brake horsepower-hour when the engine is working at full power, and assuming that with a modern steam engine and boiler the consumption of coal is 1.25 pounds per indicated horsepower per hour (which he says corresponds to about 1.47 pounds per brake horsepower-hour), the weight of fuel to be carried for the same voyage in a vessel fitted with Diesel engines will be only 28 per cent. of the weight of coal necessary with the steam power.

Mr. Milton cites as the more important auxiliaries in vessels fitted with Diesel propelling machinery: Steering gear; whistle; donkey pumps for bilge and fire service; electric-light machinery; distillers; steam-heating apparatus; water-ballast pump; winches and windlass; ventilating apparatus in passenger vessels. Alternatives proposed for the steering gear, whistle, distiller and heating appliances are: (1) A donkey boiler separately fired by oil fuel continuously at work at sea for all these purposes; (2) utilizing the heat of the exhaust gases by passing them through an auxiliary boiler and raising sufficient steam for the purpose; (3) working the steering gear and whistle by compressed air from the first stage of the compressor, which would be made larger for this purpose. The second alternative, the author says, has much to recommend it in view of the great quantity of heat which passes off with the exhaust gases.

Discussion of Mr. Milton's paper was opened by Doctor Diesel, who said the marine Diesel engine of the future will be of the two-stroke type. The air cooling of the cylinders must be accompanied by a back cooling of the oil itself in apparatus of the surface-condenser type. With regard to balancing in the Diesel engine, difficulties arise, particularly at low speeds, but by adding two scavenging pumps on both ends it is possible to completely balance the engine. In comparison with the whole output of Diesel engines the proportion of marine engines is comparatively small, the most important field being in the submarine, and the Diesel engine is now being nearly universally adopted for this class of ship by all countries except Great Britain and the United States.

It is a coincidence that before the Liverpool Engineering Society, in Lancashire, in a paper on "The Economics of Steamship Propulsion," Andrew Hamilton makes special reference to the use of oil fuel. He shows that, except for special purposes and in the navy, where cost is not so important, oil fuel under present conditions can be used in Great Britain only to a moderate extent. With regard to oil engines, he says it has recently been proposed to fit a vessel with engines of 150 to 180 total horsepower. Two engines speeded at 200 revolutions per minute would cost £2200, which, with the cost of settings, oil tanks, two sets of propeller shafts, etc., will be increased to £2900. The annual fixed charges at 15 per cent. on (say) £3000 will be £450. Compound steam engines of similar power will cost £900, which, with setting, etc., will be increased to £1260. Fifteen per cent. on (say) £1300 will be £195, showing a debit of £255 against the oil engines on capital account. Taking the consumption of oil at 0.8 pound per indicated horsepower-hour, 150 horsepower would require 120 pounds per hour, which at £1 15s. per ton would amount to 1s. 10½d. per hour; the fuel for 180 days will cost £405. The cost of coal for 150 indicated horsepower, taking 3 pounds per hour at 12s. per ton, will be about £518 for a similar period. Therefore, the capital charges and cost of fuel would be £855 for oil engines and £713 for steam; but in the case of the former, credits on account of extra cargo capacity and less labor (£230) reduce the total to £625, or £88 below the corresponding figures for steam power.

[Putting the oil consumption at ½ pound per brake horsepower-hour, which is much nearer to actual performance, the fuel expense for the Diesel engines would be £203 instead of £405 and the total operating expense £423 (instead of the author's £625) as against £713 for steam.—EDITOR.]

Gas and Oil Power in Phosphate Mining

The internal-combustion engine appears to be especially appreciated by the companies operating in the phosphate-mining district of southern Florida. The Prairie Pebble Phosphate Mining Company, at Mulberry, Fla., is operating eight Diesel engine units and expects to add eight more, each having a rating of 500 horsepower. The Pierce Phosphate Company has installed a 1200-horsepower Westinghouse producer and gas engine and contemplates installing another of the same capacity during the present year. The Penbroke Company is installing two Diesel engines of 500 horsepower each and one of 250 horsepower in its plant near Fort Mead, Fla.

The Diesel engines of the Prairie Pebble Phosphate Company have made a fine record during the time they have been in use and we shall publish shortly a detailed report of their performance.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

Air Pump Valve Froze

I once had occasion to use a double-acting pump for mine purposes, using air at 90 pounds gage pressure. But I was continually bothered with the valves freezing, which stopped the pump.

Then it was the old story of burning a piece of oily waste to thaw them out and get the pump started again. This method, however, has often caused cracked and broken pumps, due to the unequal expansion.

I finally tried the scheme of tapping a ⅜-inch connection on the discharge pipe, near the pump, and leading the same around and over the air chest, branching off over each chest. Then I put in a ¼-inch pet cock about 4 inches above each chest so as to get a small stream of warm mine water to flow over the top of each valve chest while the pump was working. This ended the trouble.

W. COOKE.

Chignecto, N. S.

A Puzzling Oil Trouble

I once had an unusual experience with an engine using the splash method of lubrication.

It ran with very satisfactory results for about six months.

The crank case holds about seven gallons of oil. It was my custom to empty all of the oil out of the crank case every three weeks and renew with new oil. The dirty oil was filtered and used on the other engines.

On one occasion I had changed the oil as usual and after running about three hours a bad pound developed on the crosshead pin. This became so bad that in about half an hour I had to shut down and key up the brasses.

I started again and in two hours the engine was pounding like a steam hammer. This time I took out the crosshead pin and boxes and found that while there was nothing hot and no apparent cutting, the oil grooves in the boxes had completely disappeared. I dressed up the boxes and the next day I had to stop three times. The third time I removed the pin and brasses and found that the oil grooves were gone again, and the pin so badly flattened that it had to be turned up. This trouble continued for some time. I changed oil again and again, but the pound still remained.

I was badly puzzled, and, while looking in the side door in the frame, I saw tiny particles of zinc floating on the oil.

I stopped the engine and keyed up again and after getting some oil from one of the other engine rooms started again, and, presto, the trouble was gone, and the engine ran nine weeks before the crosshead pin needed keying up again.

I then suspected the cause of my trouble and, procuring some barium chloride, made a test and found the oil strongly impregnated with sulphuric acid.

The crosshead boxes were of a composition containing about 90 per cent. zinc, for which sulphuric acid and water have a strong affinity.

On starting up with the new oil there was no water present and in consequence the contained acid remained inert. The metallic packing on the piston rod allowed a little water to escape and travel along the rod, whence it dropped down inside of the engine frame and mixed with the oil.

After a couple of hours sufficient water accumulated to form a corrosive mixture when combined with the acid, and this combination is what caused the brasses to waste away so rapidly.

I ran this engine for about 18 months after that, and never had a recurrence of the trouble, as I took the precaution to test each barrel of oil. I rejected two which I found contained traces of acid.

On taking up the matter with the chemist of the oil works which furnished this oil, he stated that through some error the acid had not been properly neutralized after the oil had been bleached.

The babbitted bearings of the engine did not show any ill effects and I do not think any such trouble would occur without this particular combination of zinc, acid and water, as this oil gave perfect satisfaction when used on Corliss engines with babbitted bearings.

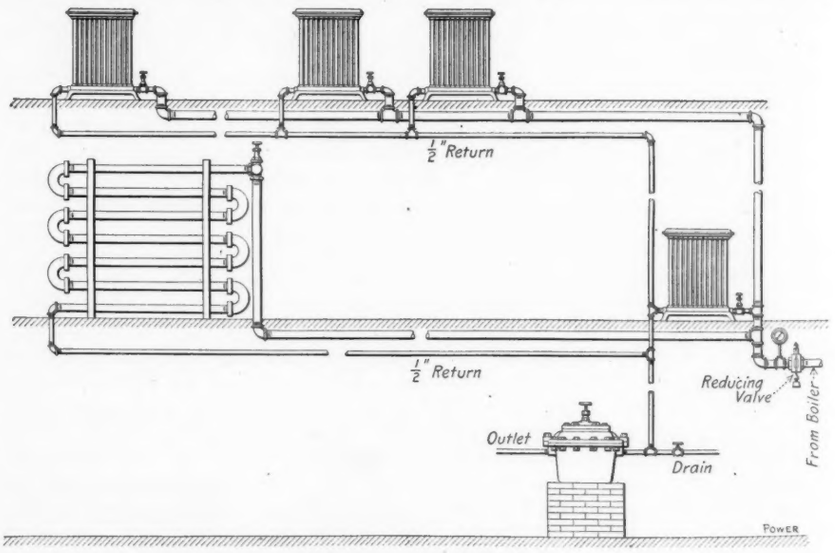
C. A. GREEN.

Cleveland, O.

Radiators Give Trouble

The accompanying illustration is of a heating system with which I have been having trouble because three radiators on the second floor fill up with water.

When I open the drain from the trap the water drains out and the system works all right for from 8 to 15 hours before it will fill up again. The radiators on the first floor give no trouble. The 1-inch line from the boiler to the first radiator is 80 feet long. Can any reader of POWER tell me how to remedy the trouble?



RADIATORS AND PIPING

B. E. THOMAS.

Seattle, Wash.

Slovenly Pumping Plant

Shortly after my arrival in this country I got a position as fireman in a pumping station not far from Philadelphia.

The plant contained five water-tube boilers, two 5,000,000-gallon pumps, two centrifugal pumps and a 15-kilowatt generator direct coupled to a high-speed engine. The working force was divided into three shifts, each being made up of an engineer, fireman and a man to look after the filters. Only two boilers were under steam and it was a hard job to keep up the pressure.

After a while I began looking around and I found that the whole outfit was in very bad condition. The pumps were running with the drip cocks wide open, and the centrifugal pump made a noise like a triphammer. To keep the boxes cool and save oil, a ¾-inch water hose was supplying a stream of water to them.

The engineer in charge paid absolutely no attention to the temperature of the feed water. The blowoff cocks leaked so badly that the water ran out of the blowoff pipe in a small stream.

I kept the job until the end of the season and then I left. A year later I passed by this same plant and, looking in, I saw the same chief sitting in the same rocking chair. No change was apparent in the conduct of the station, except that it was more dirty and noisy.

The chief did not propose to kill himself for $55 a month, working seven days a week.

LAISSEZ FAIRE.

Paterson, N. J.

What Causes the Pipe to Wear?

On a hydraulic dredge used for harbor work, the first 60 feet of the discharge pipe from the hydraulic pump consists of cast-iron pipe 25 inches in diameter. This pipe runs along one side of the dredge in a horizontal position and connects with the pipe leading to the scows into which the material is discharged.

The pipe was originally 1¼ inches thick, but after being in use for about 18 months it began to leak at several points along the top. On examination the pipe was found to have been worn to a thickness of but ¼ inch along the top for its entire length; the bottom, however, showed no signs of wear.

The material pumped through the pipe is a combination of mud and sand and the pump discharges against a pressure of approximately 30 pounds.

The engineers would like to know why the wear comes on the top of the pipe instead of on the bottom.

S. KIRLIN.

New York City.

Equalizing Pipe on Separator

Put a funnel into the neck of a bottle, as in Fig. 1, and pour water into it. The water will run freely into the bottle for

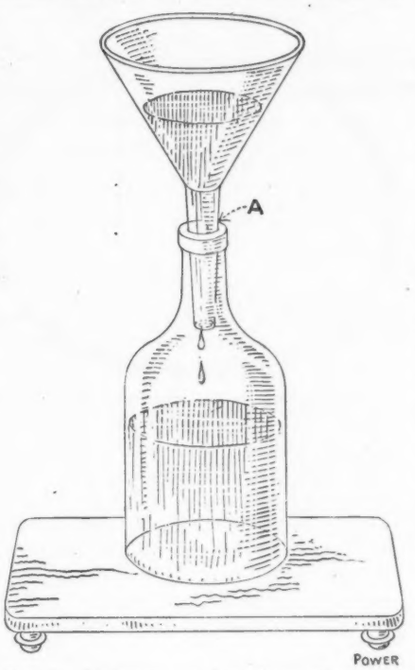


FIG. 1. ABSENCE OF AIR VENT PREVENTS WATER FROM FLOWING INTO BOTTLE

a time; but, if the joint at *A* is tight so that no air can escape, the air in the bottle will soon become compressed until its pressure equals the head of water in the funnel and then the flow will stop or

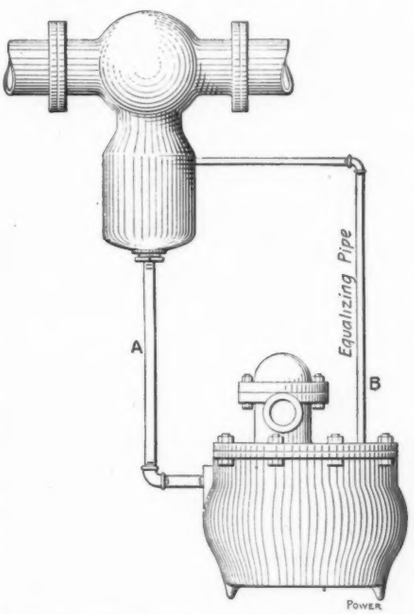


FIG. 2. SHOWING CONNECTION BETWEEN SEPARATOR AND TRAP

reduce to a dribble. If a sufficient vent is made at *A*, the flow will be as free as though the bottle were not there.

A similar condition is liable to arise in connecting a steam trap, as for instance in Fig. 2. When the flow of water is small the upper part of the trap is full of steam of the same pressure as that in the separator. If a slug of water comes over, the communication between the steam spaces of the trap and separator is shut off and the pipe *A* is like the neck of the funnel. Until the steam in the trap condenses (and it may have air in it which will not condense), the free flow of the water is impeded and the trap does not act as quickly as it should.

I have avoided trouble from this source in a number of instances by connecting the top of the trap to the steam space of the separator or whatever else is being trapped by an equalizing pipe *B*. This allows the water descending in *A* to push the steam or gaseous contents of the trap around through the pipe *B*, allowing the water to fall freely into the trap and the trap to work promptly and energetically to its full capacity. Furthermore, it takes care automatically of the venting of the trap, avoiding the necessity of getting down to it if it is in a pit, or of the trouble which may arise from neglecting it.

C. E. SQUIRES.

Cleveland, O.

Deterioration of Boilers

Boiler explosions continue to occur daily, and the reasons and excuses for them are numerous and varied. I have been an advocate of clean boilers and clean water since the time I was personally concerned in an explosion caused by foul water, and have every reason to believe that many explosions are due to this cause. My theory is that more explosions are caused by foul water than from any other cause, not excluding overheated plates which come from filthy boilers.

Not long since, a tube was removed from a vertical water-tube boiler. This tube was coated with a hard scale formation ⅞ inch thick. It is evident that the water-cooling effect was of little or no value to the tube. Crystallization will take place under just such conditions as this. The tube will lose its strength and will yield possibly under one-fourth of the pressure that it will when the flue has been kept in contact with the water.

In shearing boiler heads from some steel and iron boilers recently it was found that the lower half of the steel head was of good, tough character, especially on the water side. The other half, away from the water side and above the water line, which was subjected to the heat of the steam, was like tempered steel and would snap before it would bend. This indicates that a steel boiler in aging may become very brittle. The life of a boiler depends upon working conditions and the abuse it receives.

In one instance a water-tube boiler was run with water that formed a hard scale. Soon small leaks appeared around

the rivet holes, due to small cracks. It was found necessary to remove the heads and upon examination it was discovered that the cracks reached out from the tube holes. In the tube a hard, flint-like scale was found from $\frac{5}{16}$ to $\frac{3}{8}$ inch thick on the interior of this tube and the header was also badly coated.

Pitting is another element of deterioration. In one instance the top of a boiler was covered with asbestos. Upon uncovering the boiler in order to reset it in a new battery, it was discovered that pitting had occurred on two of the top sheets. The dome connection was also in the same shape. The original thickness of the plate was $\frac{7}{16}$ inch and some of the pits were $\frac{1}{4}$ inch deep.

A coat of graphite will form a surface under the outer covering which will prevent the metal from being attacked in this way.

C. R. McGAHEY.

Baltimore, Md.

Furnace Questions

Why is it that more letters are not written regarding the CO_2 question? There have been many articles on the theoretical side. Now let us hear from the men who plug up holes and crevices in the boiler setting, and who crawl around in furnaces studying grate areas and fire arches. They should know something about the question. Talking of furnaces, how much can the air spaces in the dumping plates of Roney stokers be reduced without danger of burning?

How can I stop or reduce the leakage of air through the joints of the big doors at the rear of a Babcock & Wilcox boiler?

If a return-tubular boiler has an air space in the setting, does not air leak into the furnace from the air space? Has anyone tried filling up the air space, and what was the result?

WILLIAM E. DIXON.

Malden, Mass.

Cleanliness in the Power Plant

One of the most important details about a power plant is cleanliness. The chief engineer of a plant has much to do in this regard, because others connected with the plant will follow the example set before them.

A young man starting in as an oiler is quick to acquire the habit of smoking a pipe and chewing tobacco if his engineer does. He will spit on the engine-room floor if he sees the engineer do so. He will acquire the habit of sitting around reading newspapers just because the example is before him in the person of the engineer. He will go around the bearings regulating the oil without the sign of a piece of waste. He will fill his oil cups without paying attention to wastefulness, forgetting to wipe the can before setting it down. The result is a general smear just because the fellow has seen his engineer do so and probably because he belongs to the class of men who are not naturally clean.

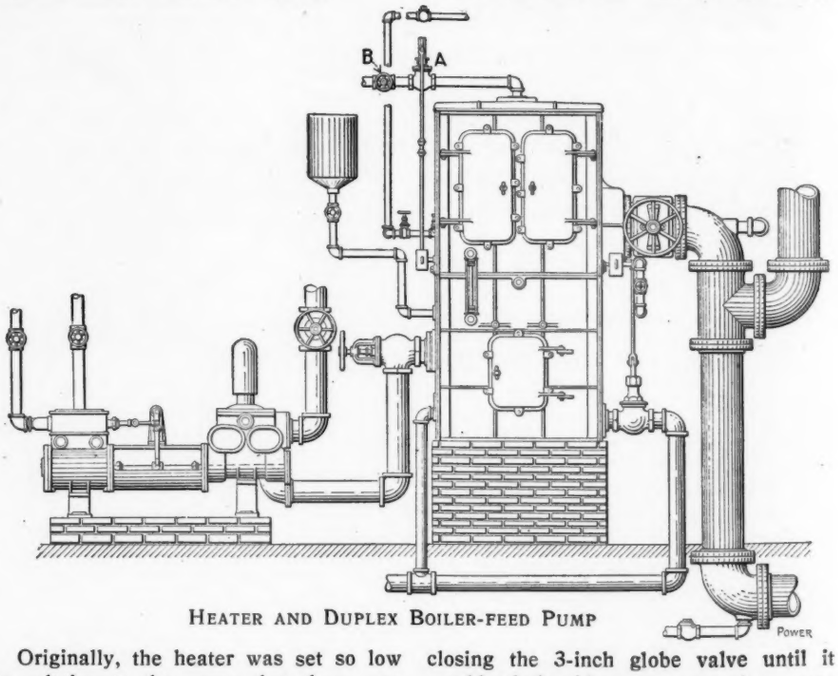
Some fellows learn by experience to keep clean, others do not. The slovenly have usually been brought up that way and never possessed any horse sense. No plant can be successfully operated without system, and the sooner the young engineer thoroughly comprehends its meaning and applies it to cleanliness, the better it will be for himself and all parties concerned.

THOMAS M. STIRLING.

Middlebranch, O.

Feed Water Regulation

In the power plant where I am employed there is a vacuum feed-water heater connected as shown in the accompanying illustration. The pump that supplies this heater also furnishes water for an outside line, on which it is necessary to carry as high as 80 pounds pressure per square inch. Since assuming charge of the plant, I have had some interesting experiences with the heater and the duplex boiler-feed pump.



HEATER AND DUPLEX BOILER-FEED PUMP

Originally, the heater was set so low in relation to the pump that there was not sufficient pressure to lift the intake valves. When the water was hot this condition caused steam pockets to form and the pump "kicked." The engineer or his assistant would have to step lively and close the throttle valve on the pump, and then admit some cold water to the heater to relieve the trouble. This was not pleasant for the fireman, for it kept him continually guessing as to the feed-water temperature and was also far from economical with the fuel supply. In addition to this the feed-water temperature fluctuated greatly as the demand of the boilers varied, this being due to the heavy rush of water into the heater as the regulator valve *A* opened, and the inability of the exhaust steam to properly heat this sudden supply of water.

Here were two difficulties to be overcome, but a third one appeared. Every time the regulating valve *A* was about to close or open it would chatter so fiercely that it could be heard some distance outside of the plant and also caused a commotion in the water pipes running to the office building some distance away. To remove the first difficulty, the heater was raised about 40 inches, and there has been no further trouble with the feed-water pump. In removing this trouble all complaints coming from the fireman were silenced and a saving in fuel was also made.

The 3-inch globe valve *B*, placed just beyond the regulating valve *A*, had always been kept wide open. This put the whole line pressure on the regulating valve and caused it to chatter, as mentioned. Then as the regulating valve opened there was such a rush of cold water into the heater that the temperature of the feed water to the boilers varied greatly.

This difficulty was removed by simply closing the 3-inch globe valve until it would admit only water enough to supply the heater with the regulating valve wide open. The globe valve had to be adjusted occasionally to meet the varying demand of the boilers, but this was very easily done. The chattering of the regulating valve is only a memory and it is now possible to maintain the feed-water temperature above 200 degrees Fahrenheit.

These were very simple remedies, but they may be of some service to the readers of POWER in solving other difficulties that may arise.

C. D. ELDREDGE.

Fairport Harbor, O.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Prevented Water Hammer

Under the above heading, A. Stevens tells on page 573 of April 11 POWER how he drained the water from an exhaust pipe under vacuum. The apparatus he employs is very crude and must require considerable attention. The same thing can be done automatically by means of a return trap such as is used for boiler feeding.

A check valve should be provided in the drain from the exhaust main to the trap and a second check valve in the connection to the feed tank. The former valve should open toward the trap and the latter away from it. In operation the condensation comes down to the trap through the drain pipe, equilibrium being established through a vent pipe connecting the trap with the exhaust main.

When the trap is full, the float rises, operating a trip valve which closes the vent and admits live steam at boiler pressure to the interior of the trap. The check valve in the drain closes and the other opens, so that the water in the trap is forced out until the lowering of the float moves the trip valve in the opposite direction and reëstablishes connections with the exhaust main.

W. T. MEINZER.

Brooklyn, N. Y.

Graphite as a Scale Preventive

I agree with E. G. Trumbo, in his article of April 4, when he praises the use of graphite in boilers to keep the scale from sticking to the metal.

From personal experience and application I know that graphite will prevent scale from sticking to the shell so hard. This property of graphite in itself is a great help to engineers in keeping their boilers clean.

In a power plant of six Babcock & Wilcox boilers, four were run 24 hours daily while the other two were out being cleaned. After being thoroughly cleaned, 10 pounds of graphite were equally divided between the two drums of each boiler, the boilers were sealed, and put into service and two others cut out. When drained out and opened up, considerable scale was found in the mud drum, and when the cleaner was run through the tubes every vestige was removed. On examining the scale the graphite could be seen clinging to the under side, showing that it prevented the scale from sticking.

FRED L. WAGNER.

Chicago, Ill.

The Giddings Engine Valve

Regarding Mr. Stock's engine valve, I have noted the remarks of several writers who have had some experience with the Giddings balanced valve, and C. A. Cahill's letter in the May 2 number is quite clear, but there is no reason for the abrupt notch in the compression line.

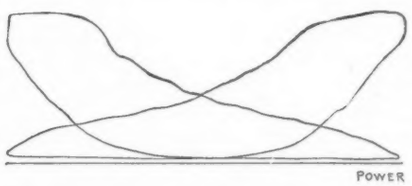


FIG. 1. DIAGRAMS TAKEN WITH LOAD BELOW NORMAL

While his explanation is correct, I am presenting two diagrams which I took on one of these engines while it was on the testing blocks. The writer had this engine changed by putting in an offset key in the governor wheel, but the diagrams were taken before advancing the eccentric. This change made the admission much sharper and better. In the diagrams the compression lines are good and also the release. The balancing of this valve was a difficult job, and the successful running of the valve depended upon this.

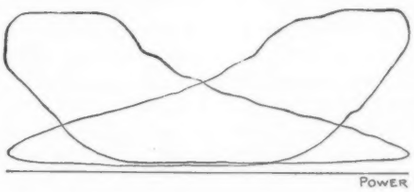


FIG. 2. FULL-LOAD DIAGRAMS

Mr. Stock's suggestion of having a bypass pipe for stopping and starting is good. I always fitted the new engines going out with this arrangement. For successful running, both springs in the governor must have the same tension. This can be determined by striking the springs with a light hammer and listening to the sound; the tighter spring will give a higher tone.

C. R. MCGAHEY.

Baltimore, Md.

Asleep on the Job

The foreword in the March 14 issue regarding the engineers who fall asleep on their job hits the nail squarely on the head. How many would-be engineers are dozing? Then when caught by their employers or other persons on the watch, they will put the blame on someone else.

The time has passed when an engineer can afford to fall asleep on his job. The Edison or central-station interests are not to blame if some day the sleeper wakes up and finds them on his job.

Organizations and knocking are not the things needed. Employers are entitled to facts, figures and results. Work therefore should be done so that it will command as much respect as the work of professional men. It may be asked why do employers look at it in this way now any more than formerly? Well, because the general operating expenses are on the increase. Supply bills and wages are higher. The outside man is giving this as an argument. It is a catchy one. He makes it appear as if all trouble ends with the putting in of outside service. It sounds well when told by him, and, mind you, he has his piece well learned and can tell it. Then the "boss" comes after he has been posted and wants to know how much coal is burned per kilowatt-hour; how many B.t.u. are in the coal; perhaps, something of the CO_2, or how many pounds of water are evaporated per pound of coal used? What do you do? Have you any reports showing daily results, anything to fall back on? Can you produce facts which may send your "boss" back to his outside friend and shut him up for good? I am afraid not.

If you want to better your job, you should keep daily records. In this way you may be able to hold the coal man in place and know just what you are doing. You will have a check on your firing and plant conditions.

The isolated plant is all right. But the isolated-plant engineer must keep awake.

This is an age of energetic competition. You must work hard to keep abreast with the leaders or fall behind.

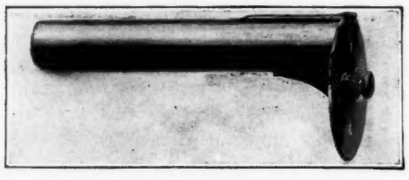
ASA P. HYDE.

Binghamton, N. Y.

Measurement of Smoke Density

The construction of the smoke tintometer, as mentioned in the April 25 issue of POWER, is essentially the same as that of the smoke meter described by the writer in the London *Engineer* of January 31, 1908. I believe, however, that my instrument has superior qualities, one of which is that its simplicity permits it to be more readily made by anyone who may wish to possess a smoke meter.

As shown in the cut, the Kunze smoke meter consists of a metal tube 6 inches long and 1 inch in diameter, at the end of which is a disk similar to that of the smoke tintometer. I made the first disk of glass, but finding this expensive and easily broken, I used transparent celluloid. Only four tints were employed as the grades "clear" and "black," corresponding respectively to 0 and 5 of the Ringelmann chart, were unnecessary to operation. The grades 3 and 4 are most vital, as they constitute a violation of city ordinances as usually drafted. If the smoke appears darker than grade 4, it may be recorded as 5, and if no smoke is seen the record 0 may be used.



THE KUNZE SMOKE METER

At first I tinted my disks by painting them, but I found it difficult to get a flat tint without streaks or spots. A better way is to tint the disks by photography. The four segments of a large circle drawn on a sheet of bristol board are tinted corresponding to the grades 1, 2, 3 and 4 of the Ringelmann chart; this is then photographed and printed on a sensitized celluloid disk. By using an arc light for printing, one can time the exposure so accurately as to secure uniform grades of tints for any number of prints, and the tints after being fixed are not easily destroyed through use. Should it be desired to further protect the tinted surface, it can be done by having the celluloid disk turned out, leaving a small rim around the edge and, after sensitizing and printing the inner surface, covering it with a glass disk, in this way protecting the glass from breakage by the celluloid. In calibrating the different tints with the Ringelmann chart the instrument is used in its usual manner.

In employing any of the methods of tint comparison, including that in which the Lowdon instrument is used, a difficulty arises in that so many conditions may change the appearance of the smoke: the condition of the background, the color of the sky, the time of day, the position of the sun and many other conditions which will widely alter the effect of the observation. This trouble is mostly due to the fact that the eyes of the observer are not concentrated upon the smoke and the tint with which it is being compared, but are influenced by foreign conditions such as those named. This objection was overcome in the Kunze smoke meter through the use of small holes in the center of the tints as presented in front of the tube. In using the instrument the observer looks through the tube with one eye, and closes the other. The smoke will be seen by the naked eye through the small hole in the center of the tint and as all background is cut off there will be no disturbing influences and an exact comparison can be made. The disk is turned around its axis until the shade of smoke proper corresponds to the tint on the disk, or most nearly to it. If the smoke is darker than the surrounding tint, a dark spot will appear in the center. If the smoke is lighter, the spot will appear to be quite light in comparison. The contrast is great until the shades correspond to one another, at which time the contrast suddenly ceases to exist and the tint at the end of the tube is unbroken.

The use of this instrument need not be confined to smoke observations but may be used to compare color tints as readily as it does shades of grayness.

EDWARD J. KUNZE.

East Lansing, Mich.

Standpipe on Heating System

With reference to Alexander Dolphin's letter under the above title in the May 9 number, I do not think that the standpipe would give satisfaction. I think that the system would always be filled with water and that there would be violent water hammer. There could not be good circulation and the service would be poor. If it would be convenient to get below the return line a water seal in the shape of a U-bend would make a good form of trap. I have used a U-bend for a trap on low-pressure lines with success. It is bound to drain all the water out of the line, and it will not permit any steam to escape. There would be an objection to this trap for Mr. Dolphin's system which carries as high as eight pounds pressure, in that it would be necessary to extend the bend down about 18 feet below the return line in order to prevent the steam pressure from overcoming the weight of the water in the trap and thus allow steam to escape.

WILLIAM SWOPE.

Tiffin, O.

In the May 9 number of POWER Alexander Dolphin seeks information concerning a standpipe on a heating system. There is this objection to a standpipe. If he has a single-pipe system, every time the steam pressure goes off, the water in the standpipe will run into the radiators below the level of the water in the standpipe, and when the steam comes on again it will blow the remaining water out of the standpipe and cause severe pounding in the radiators. Then the water in the radiators must be removed, and this is no easy matter.

If he has a double-pipe system the steam pressure will clear the radiators of water but will cause much pounding and if there are any pockets he will find that the radiators behind the pockets will be flooded.

Then, too, with either system of piping, he will have a job to keep the proper head of water to balance the steam pressure. Five pounds on the steam mains will require 11.5 feet of water in the standpipe, measured above the lowest point in the steam mains; eight pounds will require 18.4 feet of water.

If the end of the pipe were in plain view it would be possible to put on a valve and throttle it, using it as a bleeder. Another way would be to use a water seal which can be made by taking two ¾-inch pipes about 20 feet long, laying them parallel and connecting them at one end with two elbows and a short nipple. Then place them upright and connect one end of the U-bend to the return main and let the other end discharge to the tank. This trap will keep the radiators clear of water and will prevent steam from blowing through.

ROY V. HOWARD.

Tacoma, Wash.

To Engineers Who Write

Much advice and exhortation have been devoted to those engineers who do not write. Just a word to those who do.

Many hesitate to write because they fail to see that what seems commonplace to them is just what some other fellow is aching to know. Others hesitate on account of lack of confidence. Then, too, a proposition reduced to black and white usually loses much of the force and luster it had while it was only an unexpressed thought. All these and more may account for the fact that some writers of letters stop right in the midst of their story.

For example, take the letter of C. B. Smith on page 646, April 25 number, on "Reduced Compression and Lead Saves Coal." Now, I happen to know the two engines of which he speaks. It also happens that I am running three engines of the same make. Naturally I am interested. Mr. Smith found it possible to save 3000 pounds of coal per day. If we could turn the same trick here, it would give us great pleasure. But here is the hitch. I know how my valves are set; but Mr. Smith has failed to show how his were set, either before or after adjustments. Possibly my compression is

the same as his after adjusting, or my lead may be the same as his before adjusting. I do not know; he has left me in the dark.

A set of cards taken as the engines were originally and another set as they were when saving 1½ tons of coal per day would be relevant, or measurements of lap and lead and compression might be given. With such information the letter might be made very valuable to the many who are operating Rice & Sargent engines. Without it, all we know is that one man used a wrench and saved coal.

I have taken Mr. Smith's letter, not to cast any doubt or reflection upon it, but because it is easier to make one's meaning plain by using a concrete example. His fault is quite common. Let every writer try to put himself in the place of the "other fellow" for whom he is writing.

The admonition "Be brief," frequently given to writers, may be the reason for some of these letters which contain only half the story. We readers do not like to wade through a lot of verbiage to get at an idea. We want the ideas clearly set forth; but we want all of them. It may not be possible to do that and be brief; so I say, be concise. Get all the essential facts—and then prune.

WILLIAM E. DIXON.

Malden, Mass.

Coal Defined

In my letter under the above heading which appeared in the May 30 number I neglected to cross out the words "noncombustible elements" in the last equation of Table 2. The equation should read:

Pure Coal = Combustible Elements.

WILLIAM KENT.

New York City.

Benefit of Organization

Under the above caption in POWER of April 11, there appeared an article signed by C. C. Harris, of Springfield, Mass., calling attention to an organization of firemen, oilers and engineers to be known as the Brotherhood of Power Workers. I assume it is a local benefit association organized for the purpose of caring for the sick and burying the dead. How this will benefit the power-plant worker as a worker I fail to see.

For some little time there has been a movement to organize the Institute of Operating Engineers. This organization is to be composed of all men associated with the power plant. Assuming that all power-plant employees from coal passer up will eventually become engineers, it is therefore an engineers' organization.

The purpose of the Institute of Operating Engineers has been explained at length in POWER and is the kind of organization the engineer sadly needs.

Through its system of lectures, grades and certificates, the apprentice may become in time an operating engineer and in turn receive his certificate of master operating engineer.

The present standing of the average engineer is due, in part at least, to his isolation and his short-sightedness. He has been left out of the general distribution of rewards and is therefore compelled to accept a lower wage than some of those over whom he has supervision.

When the standards set by the Institute of Operating Engineers are established, there will be a recognized distinction between the engineer in charge of a 25-horsepower plant and the chief of a large central station.

The man who will be able to obtain a certificate of master operating engineer, will have in his possession a paper of value and his services will be in demand. His compensation will be in accordance with his ability.

J. P. FLEMING.

Chicago, Ill.

The Accident at Amoskeag Mills

In reading over the account in the April 11 issue of POWER of the accident at the Amoskeag mills, and the resulting death of three men, it seemed almost incredible that the two men on the engine-room floor were unable to get out of the building before being enveloped by the escaping steam. A little figuring, however, leads one to wonder how anyone was able to escape.

The only measurement given is the length of the basement, 151 feet. If the drawing is to scale, the width is 80 feet. The basement is probably not over 10 feet high and the engine room about 40 feet. These assumptions are sufficiently close for the information desired. This gives 600,000 cubic feet as the total cubical contents.

About one-fourth of the flange blew out, so that the area of the opening was 78.5 square inches. Using Napier's formula, the quantity of steam flowing through this opening in one minute, with a boiler pressure of 170 pounds, would be

$$\frac{185 \times 78.5 \times 60}{70} = 12{,}450 \text{ pounds}$$

One pound of steam at atmospheric pressure is equal to 26.8 cubic feet, so that in one minute 331,000 cubic feet of steam at atmospheric pressure would be blown into the basement and engine room. This would mean that in less than two minutes the entire building would be full of steam at a temperature of 212 degrees Fahrenheit, high enough to kill a man in a few seconds. Actually the engine room must have filled with steam to a hight of 10 or 15 feet inside of 45 seconds, and the men, unable to see, must have been caught before they could grope their way out.

W. L. DURAND.

Washington, D. C.

Triplex Pump Problem

In Mr. Potter's triplex-pump problem in the March 28 number, let us assume two different positions of the cranks as in Figs. 1 and 2. Let the connecting rod be four times the length of the crank, then when one of the cranks is on the bottom center the end of the plunger will be five crank lengths from the center of the crank shaft. The stroke of a plunger will equal two crank lengths and if for the sake of argument we call a crank length one volume, the stroke will equal two volumes.

The cranks, the connecting rods and the center lines of Figs. 1 and 2 will form a number of triangles. If the length of the center line forming one side of the triangles in Fig. 1 is determined and this distance measured from the center of the crank shaft, it may be determined how far up the end of the plunger has moved. By the use of the sine tables and the rule that the sides of any triangle are proportional to the sines of the opposite angles, I find that in Fig. 1 two plungers have displaced 0.5949 volume each, while the other plunger, being at the end of the stroke, has displaced two volumes, the sum of the three being 3.1898.

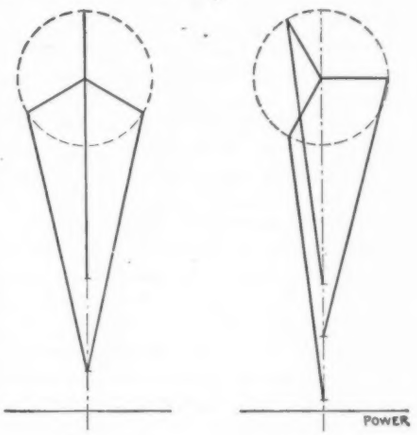


FIG. 1 FIG. 2

In Fig. 2 one plunger displaces 0.16531 volume, another 1.12696 volumes and the other 1.89745 volumes. The sum in this position is 3.18972. The shorter the connecting rod the greater becomes the effect of the angularity. With a connecting rod twice the length of the crank, I obtained 3.525 volumes for Fig. 1 and 3.34303 volumes for Fig. 2. While the difference in volume for the two positions is not large, when the cylinders are filled with water I think that something would have to let go.

LESTER FITTS.

West Fitchburg, Mass.

Value of CO_2 Recorder

In the issue of May 9, H. S. Vassar presents diagrammatically the results of a number of boiler tests for the purpose of confirming his disbelief in the value of flue-gas analyses in general, and automatic CO_2 recorders in particular. He starts out by placing these instruments in a class with pies and puddings—which are unnecessary, if not indeed harmful, luxuries—and clinches his arguments by citing a fable which represents all those who are spending time, effort and vocabulary in an earnest endeavor to show the true relation between CO_2 and efficient combustion, and to convince the power producer of the economic value of a continuous automatic record of CO_2, as "strangers glib of tongue" who are enticing the foolish managers of power plants into ordering these instruments "at a fabulous price" and all those who for many years have been spending time, money and patient, toilsome effort to perfect such instruments as "weavers of airy nothingness from nothing."

Mr. Vassar's presentation of experimental data is not without value.

First, because it shows how easy it is to draw false conclusions from insufficient data.

Second, it gives an opportunity to discuss the subject of CO_2 from a new viewpoint.

Third, and most important, it sets those who are, or should be, interested to thinking.

Valid conclusions cannot be drawn from the meager data presented. It is necessary to know the draft, rate of combustion, feed-water temperature, steam pressure, the percentage of superheat or moisture in the steam and, above all, the temperature of the flue gas and the percentage of coal left in the ash and clinker.

It is absurd to condemn the value of an automatic CO_2 recorder from the results of a series of tests in connection with which no such records were made. An average sample may be quite misleading because it cannot reveal what has happened during the sampling period. In an average sample showing 11 per cent. of CO_2 the flue gas may have varied between 5 and 17, 8 and 13 or 10 and 12 per cent., and unless these variations are known, valid conclusions cannot be drawn as to the economic value of CO_2.

Furthermore, the ordinary method of sampling by drawing the gas into a bottle filled with water and allowing the water to drain off gradually does not give a true average sample. The flow of gas varies inversely with the draft, and directly with the loss of head in the bottle, causing the flow to become less and less rapid as the bottle empties. Until Mr. Vassar gives assurance to the contrary, there is justification in doubting that he obtained true average samples.

Mr. Vassar says nothing about the temperature of the flue gas and, since the loss of heat up the chimney varies directly with the temperature of the escaping gas, no valid conclusion can be drawn without this knowledge.

The loss of coal through the grate bars is another factor which may vary between 1 and 5 per cent. and must therefore be taken into account. Without a knowledge of these factors it is absurd to draw a general conclusion. There are certain fundamental principles and natural laws with which experimental results must harmonize, and if they do not so harmonize, there is something wrong with the results or the manner in which they have been obtained.

To burn 1 pound of carbon to CO_2 requires 11.6 pounds of air, forming 12.6 pounds of combustion product composed of 21 per cent. CO_2 and 79 of nitrogen by volume. If 50 per cent. excess air is supplied the products of combustion will weigh 18.4 pounds and contain 14 per cent. of CO_2. With 100 per cent. excess air the products of combustion will contain 10½ per cent. CO_2 and weigh 24.4 pounds. With 200 per cent. excess there will be 7 per cent. CO_2 and 35.8 pounds of flue gas; and with 300 per cent. air, 5.25 per cent. CO_2 and 47.4 pounds of flue gas. Thus the weight of the flue gas increases as the percentage of CO_2 decreases.

In burning 1 pound of carbon 14,500 B.t.u. are liberated, and this quantity of heat remains the same whether the coal is burned to CO_2 with the theoretical minimum weight of air required or with an excess of 300 per cent. or more. There is therefore a definite quantity of heat available from every pound of carbon burned, irrespective of the excess of air supplied.

To raise 1 pound of dry flue gas 1 degree, requires 0.24 B.t.u. If the temperature of the escaping flue gas is assumed to be 500 degrees above atmospheric temperature, 1 pound of flue gas will carry away

$$0.24 \times 500 = 120 \textit{ B.t.u.}$$

Therefore there must be loss of heat up the chimney. The following gives the losses for various percentages of CO_2 in the flue gas and also the percentage of these losses to the total heat produced:

CO_2, 21.0% $12.6 \times 120 = 1512$ B.t.u. or 10.4%
CO_2, 14.0% $18.4 \times 120 = 2208$ B.t.u. or 15.2%
CO_2, 10.5% $24.4 \times 120 = 2928$ B.t.u. or 20.0%
CO_2, 7.0% $35.8 \times 120 = 4296$ B.t.u. or 29.6%
CO_2, 5.25% $47.4 \times 120 = 5688$ B.t.u. or 39.2%

These are minimum figures for the stack temperature assumed, and can be reduced only by reducing the stack temperature.

The loss up the chimney may be and generally is greater than shown in the table, due to various causes: First, higher stack temperature; second, unconsumed combustible gases, and, third, water vapor.

Abnormally high stack temperature may be due to dirty and insufficient heating surfaces and excessive driving. With a properly constructed furnace and intelligent firing, appreciable quantities of unconsumed gases will not occur when 40 to 50 per cent. of excess air is used. Water vapor is always present, due to moisture in the coal and the air and to the combustion of hydrogen.

In all cases high or low CO_2 means high or low efficiency, and when, as some of the tests in Mr. Vassar's diagrams indicate, 5.25 per cent. CO_2 gives a higher efficiency than 8 per cent. (Fig. 1) and 8 per cent. is more efficient than 12½ (Fig. 2), there is something wrong either with the percentage of CO_2 given or the determination or computation of the other data.

While it would be preposterous to say that a CO_2 recorder is a sure cure for all sources of loss in the boiler room, it is none the less true that it is the most available and most reliable, and hence the best, guide to efficient firing, and in combination with a recording pyrometer gives a correct measure of the loss of sensible heat up the chimney. When it is considered that this constitutes from 60 to 90 per cent. of the total waste in generating steam, its importance must become evident to all concerned in boiler-house economy.

EDWARD A. UEHLING,
President Uehling Instrument Company.
Passaic, N. J.

The Line Shaft Breaks

In the issue of May 2, A. Rathman writes that the shafts break in the hub of the sheaves. That is the weakest place, as the keyseat is cut there.

An uptodate factory which had been installed but a short time was operated by a rope drive. The generator was driven by a Corliss engine of 1500 horsepower.

One night during a rain storm the wheel pit was flooded and the rope got wet and began to shrink. It was then slacked off all that was possible on the tightener. The stress was so great that a coupling on the generator shaft was sprung, cracking one bearing, and the rope drive had to be cut out to keep it from pulling the generator off its base.

Mr. Rathman does not say whether the plant was run 10 hours or 24 hours, but I infer that it is operated in the daytime. At night the drive is apt to get damp and contract, causing a heavy strain or even springing the shaft. The remedy I suggest is to keep the drive as dry as possible. A good belt dressing might be a help to prevent moisture, if applied when running slowly just before shutting down.

O. L. SHERMAN.
Duluth, Minn.

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Contents

PAGE

Horsepower of a Fan Blower 904
Defects in Welded Flanges 905
Determining the Most Economical Vacuum 906
Wave Motors and Compression 907
Overcoming a Pound in the Cylinder 908
Test of a High Duty Pumping Engine ... 909
Corrosion of Steam Boilers 910
Boiler Plant Considered as a Factory ... 911
Progress in Return-Tubular Boilers 913
Determining the Value of Fuel 914
A New Interpole Dynamo 916
National Electric Light Convention 917
Conduit Wiring Data 919
Taking Gas Samples with an Aspirator .. 920
Oil Engines for Ships 921
Gas and Oil Power in Phosphate Mining 921
Practical Letters:
Air Pump Valve Froze....A Puzzling Oil Trouble....Radiators Give Trouble....Slovenly Pumping Plant ....What Causes the Pipe to Wear? ....Equalizing Pipe on Separator ....Deterioration of Boilers....Furnace Questions....Cleanliness in the Power Plant....Feed Water Regulation 922-924
Discussion Letters:
Prevented Water Hammer....Graphite as a Scale Preventive....The Giddings Engine Valve .... Asleep on the Job .... Measurement of Smoke Density .... Standpipe on Heating System .... To Engineers Who Write....Coal Defined....Benefit of Organization....The Accident at Amoskeag Mills....Triplex Pump Problem....Value of CO_2 Recorder ....The Line Shaft Breaks..... 925-928
Editorials 929-930
The Westinghouse Leblanc Water Refrigerating Machine 932
Explosion of an Ammonia Still 933
Air in Ice Water System 934
Purging the Absorption System 934
Spring Meeting Mechanical Engineers ... 935

POWER

The National Electric Light Convention

Some of the features of the "electric light" convention recently held in New York City might be profitably adopted by the other national engineering bodies. The committee system is probably the most important of these. Of about thirty items on the program relating to engineering or closely allied branches of central-station work, nineteen consisted of committee reports and most of these were far and away more valuable than any of the papers constituting the remaining eleven "events." Just why this is so we do not presume to say in detail; it is sufficient that it is true, which is indubitable. Those of the reports that are of high merit are the results of a year's almost continuous effort by the several committees making them; this is a very obvious and excellent general reason why they are of more value than the average paper. Of course, there are other reasons and anyone interested can easily discover most of them.

The committee reports this year were of a much higher order of merit than those previously returned; this is but the natural result of continuing good, earnest workers on the committees from year to year instead of disorganizing things and handicapping the work by annual upheavals. The reports on meters, power, overhead line construction, underground construction and the preservation of poles and crossarms, for example, were masterly compilations of practical information, each worth its weight in gold to any central station within the class to which it applies.

It is by no means intended to intimate that the papers read at the convention were not meritorious. On the contrary, most of them were unusually so and this fact serves only to emphasize the demonstration which this year's program makes, that a committee report can be made of more practical value to the station operator or manager than a good individual paper.

However, the fact must not be ignored that some subjects cannot be treated as well in a committee report as in an individual paper. Hence, there will always be excellent work to be done in the way of preparing papers. No hard and fast line can be drawn, but in general it would seem that the best plan of apportionment is to have principles treated in individual papers and practice reflected and guided by committee reports—not forgetting that specialization pays in committee work as well as other kinds. This policy was reflected to a large extent in the convention under discussion, with the conspicuously beneficial results to which we have referred.

Progress or Something New?

As a people the Americans attempt to be progressive to a degree not reached by any other, but all of this progress is not in the right direction. Much of it is merely change which does not represent real progress.

When an idea is developed it is frequently adopted without sufficient investigation. New processes and methods of doing work and new products are daily creations which are adopted almost as a matter of course on the assumption that that which is new must be better than that which is old.

In the test of practical operation failure is more than often the ultimate result which investigation or even logical mental analysis would have predicted.

Some years ago improvements in rolling-mill practice made the rolling of large sheets possible. Immediately two-sheet boilers were put on the market with multitudinous unsupported statements of the advantages of a boiler construction devoid of circumferential seams. Short terms of service demonstrated the fallacy of the claims in a much more costly manner than would a reasonable amount of analytical research.

Concrete, both plain and reinforced, now supplants iron, wood, brick and stone in countless forms of construction, with little regard for its fitness in many instances. It is used in buildings, beams and bridges, in pavements, fences and even steamboats and for foundations and retaining walls, but careful engineers, while recognizing its many advantages for various purposes, are advising its employment only where it is manifestly advantageous.

In power-plant equipment the piping is a factor of prime importance and the necessity for reliability has led to the design of many types of pipe joints, among which the welded flange is not the least noticeable. Though it may be possible that a pipe line in which the flanges are integral with the pipe length

is better than one with separate flanges, it is of paramount importance that the construction be safe beyond the possibility of suspicion.

When two pieces of iron or steel are to be welded together the surface must be clean so that the pasty metal may be rolled or hammered into perfect contact, and when the slag is not entirely removed from both surfaces this is impossible. There is always more or less difficulty in welding when one of the members is much thicker than the other, and this is aggravated when the surfaces to be joined are comparatively broad or long.

Between the pipe and the flange there is a considerable difference in thickness and the form of the joint is such that the removal of all of the slag and oxide is problematical. A joint of this kind though to all appearances perfect outwardly and may withstand a mild hydrostatic test, may be so imperfectly joined within that the stresses and flexures of even a short service will pull it apart.

The strength of a perfect weld may be approximately calculated, but the uncertainty of the continuity of the union between the pipe and the flange in a welded joint has led conservative engineers to discourage the use of the welded pipe flange, not because of the lack of strength and rigidity when sound, but because of the uncertainty of the nature of the union between the pipe and the flange.

Ignition in Gas Engines

It has been universally true ever since the early days of electrical engineering that electrical auxiliaries used with machines not themselves electrical are responsible for most of the troubles experienced in the operation of the machines, until the makers of them "wake up" and put the proper quality in their electrical auxiliaries. The gas engine is no exception to the rule—in fact, it is a shining example of its truth. It has been stated that more than two-thirds of gas-engine troubles are due directly to the ignition equipment; it is our opinion that the proportion is much nearer ninety per cent.

The remedy in all cases where the engine is small is to equip it with the best quality of ignition apparatus *and wiring* that money can buy. Large engines, however, suffer the unavoidable handicap of relatively slow complete ignition, no matter how good the equipment, because of the distance through which the flame must travel and the very small quantity of mixture in contact with the spark made by the igniter.

The Diesel engine has been perfected mechanically to such an extent, we are told, that it is operated in Europe by unskilled labor. Does anyone suppose this would be possible if the engine had to depend for ignition on the kind of apparatus commonly applied to gas engines? The fact that the air in the cylinder is hot enough to ignite the oil as it is injected undoubtedly accounts for the conspicuous operating success of the Diesel type of engine, now that the rubbing surfaces, crank shaft and nozzle have been made practically fool-proof.

Builders of gas engines will do well to take this lesson to heart. Ignition by means of a minute spark at one or even two points on the circumference of a large cylinder is inefficient, and attempted ignition, at one or forty points in any cylinder, by means of cheap apparatus is an insuperable obstacle to satisfactory operation.

Gathering Them In

"Twenty-nine steam plants in one town; twenty-seven of them are shut down and the other two are on the run." This is the substance of what the chief engineer of a central station in a prosperous Massachusetts manufacturing town told a POWER representative recently.

Why have the owners of these twenty-seven steam plants found it to their advantage to close them, unless it is because electrical energy is sold to them at a lower cost than the steam plants can produce the same power?

This is not a proof that the isolated plant cannot produce power cheaper than it can be bought from the central station, but it indicates that some engineers are so operating their plants that they cannot compete with central-station rates.

There is not enough attention given by private-plant engineers to the undeniable fact that their positions are in peril. They do not seem to realize that their employers are going to get power where it will cost the least. There is no sentiment in business. The owner of a steam plant sees no poetry in the roaring furnace and revolving flywheel, and just as soon as it is determined that the central-station rate is cheaper than isolated-plant operation, out goes the small plant and with it the engineer.

When the operating conditions of some isolated steam plants are noted it is a wonder that they have not been superseded by the central station long ago. Some engineers are woefully ignorant about the machinery in their plants. Recently the man in charge of a four-valve engine could not tell his visitor the maker's name until he had looked at the nameplate. In another steam plant the engineer was operating a cross-compound engine. Each cylinder was provided with two exhaust valves and each steam valve was fitted with a riding cutoff valve. The engineer stated that each cylinder had but four valves.

With such men in the small steam plant it is no wonder that the central station is putting them out of business. An isolated plant, in order to withstand the competition of the central station, must be operated by an intelligent engineer.

Two steam plants in operation out of twenty-nine is a commendable record for the central station, but what a mighty poor showing on the part of the twenty-seven engineers! A fact worth noting is that the engineers of the two live steam plants are readers of power-plant journals.

Is it not about time to wake up?

High Voltage Transmission

At a meeting of the power-transmission section of the National Electric Light Association during the recent convention the question was raised as to what is the maximum voltage that can be carried economically on transmission lines. Although there were a number of prominent electrical engineers present and the question evoked considerable discussion, there appeared to be no definite opinions upon the subject.

At one time it was believed by many that distance was a factor dependent only upon the voltage; that is, power could be transmitted almost any distance providing a sufficiently high voltage could be employed to avoid excessive copper losses. The chief difficulty then lay in obtaining insulators which would withstand the high tension; but this now seems to have been overcome and with the introduction of the suspension type of insulator it is probable that this phase of the problem will be met for any voltages likely to be used. Another factor to contend with, however, is the breaking down of the dielectric strength of the air, resulting in objectionable leakage from wire to wire through the intervening air.

In Colorado, transmission lines carrying current at one hundred and ten thousand volts are in successful operation at altitudes of ten thousand feet above sea level, and a one hundred and forty thousand-volt line is being constructed in Michigan. This represents an increase in voltage about tenfold during the past fifteen years. What then appeared to be unsurmountable difficulties have been successfully overcome and it is probable that like progress will be made in the future. Nevertheless, definite data upon the subject of leakage through the air would be of great value to engineers engaged in power-transmission work.

It is expected that in twenty or thirty years all of the water power in Bavaria will have been developed. There is a total of some three million horsepower, about one-half of which is owned by the government. One of the first large projects to be undertaken under government auspices is that at Lake Walchensee.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Feed Water Entrance to Manning Boilers.

Why does not the feed water enter the water leg of a Manning boiler as in most vertical boilers?

M. B. H.

The feed water enters the Manning boiler as it should all vertical boilers, well up toward the top of the water, in order to give the contained air a short pass to the steam space. If the water enters the boiler anywhere in the comparatively cool water leg, the oxygen in the air leaves the water slowly and collects on the staybolts and sheets and injures them by corrosion; while if set free in the hot water near the top, it goes directly into the steam space and thence to the engine, where it can do no harm.

Soda Ash and Soda Crystals

What are the comparative values of soda ash and soda crystals for water softening?

F. W. S.

Soda ash and soda crystals are on the market in such degrees of impurity that a definite answer to your question is impossible.

Soda ash runs from 40 to 60 per cent. alkali, and soda crystals may contain anywhere from 20 to 30 per cent. of water. Ordinarily, the largest per cent. of alkali is obtained for the money when 48 per cent. soda ash is bought.

Sulphur for Hot Bearings

How is sulphur used for cooling hot bearings, and is it suitable for all sizes?

C. H. P.

Pulverized sulphur, commonly called flowers of sulphur, is mixed with a heavy oil, preferably cylinder oil, in proportions by measure of about 1 of sulphur to 6 of oil. The mixture is applied liberally and is suitable for all sized bearings.

Horsepower of an Engine

What would be the horsepower of an engine: mean effective pressure, 40 pounds; length of stroke, 12 inches; diameter of the cylinder, 14 inches; number of revoultions, 90?

W. G.

The horsepower of a steam engine is found by multiplying together the speed of the piston in feet per minute, the area of the piston in square inches and the mean effective pressure per square inch and dividing the product by 33,000.

Expressed as a formula the rule is:

$$Horsepower = \frac{PAS}{33{,}000}$$

Substituting the values given it becomes:

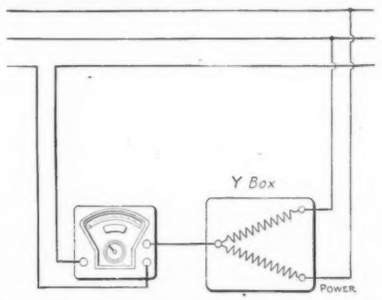
$$\frac{40 \times 153.94 \times 180}{33{,}000} = 33.58 \text{ horsepower}$$

Measuring three-phase Power with Single-phase Meter

Can the power in a three-phase circuit be measured with a single-phase wattmeter, using a constant to multiply the meter reading by; if so, what is the constant?

G. M. F.

Not with the meter alone. If the circuit is accurately balanced, one wattmeter and a Y-box, connected as shown in the diagram, may be used. The wattmeter will indicate one-third of the total power in the circuit—that is, it measures the power in one phase only. The use of the Y-box is for the purpose of giving the potential coil of the wattmeter the true voltage between the main wire and the neutral point of the system. The resistance of each branch of the Y-box conductor must equal that of the potential coil.



MEASURING THREE-PHASE POWER WITH A SINGLE-PHASE WATTMETER

Alternating-current Frequency

What determines the number of cycles per second in an alternating-current circuit?

H. E.

The number of cycles per second is equal to the number of field-magnet poles on the alternator which supplies the circuit multiplied by one-half the number of revolutions per second. For example, a machine with eight poles running at 15 revolutions per second (900 revolutions per minute) will deliver current of 60 cycles per second, because

8 poles $\times$ *7½ r.p.s.* $=$ *60 cycles.*

Same Speed at No Load and Full Load

A shunt-wound direct-current motor continues running at the same speed after the load is cut off that it showed with full load; what is probably the reason?

F. C. G.

It is probable that the brushes have a forward lead to such an extent that the armature reaction at full load weakens the field enough to keep the speed up to the no-load speed, but this would ordinarily cause bad sparking. Another possibility is that the field winding is differential instead of simple shunt. Examine the coils closely.

Removing Scale from Engine Jackets

How can I remove the scale from the water jacket of a gas engine that is so small that a scraper cannot be used in the jacket space effectively?

F. C. H.

Fill the jacket with a strong solution of washing soda and run the engine until the water becomes hot; empty the jacket and refill with pure water, not too cold, and run the engine until the water begins to evaporate (not boil vigorously); empty the jacket and refill again with pure water and run the engine as before. Repeat this until the water comes out reasonably clean. If it is rusty and dirty after the third or fourth dose of pure water, put a solution of washing soda through again and follow with the fillings of pure water as in the first effort.

Reversing a Direct-current Dynamo

What changes in connections are necessary when a direct-current dynamo is driven in the direction opposite to that for which it was built?

H. E.

Transpose the connections of the two cables leading to the brush holders and reset the brushes for the reversed direction of rotation.

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

The Westinghouse-Leblanc Water Refrigerating Machine*

This machine rests on the principle of producing cold by evaporation of an aqueous solution in a vacuum. But it differs essentially from the old machines of Leslie and Carré and from the vacuum machines now employed in America in that the water evaporated, instead of being absorbed by concentrated sulphuric acid, is removed by mechanically drawing off. This leads to a great simplification since there is no longer any need to trouble with reconcentrating by dilute sulphuric acid. If this expedient had not hitherto been devised, it was because it seemed impossible, practically, by mechanical means, to remove the enormous volumes of water vapor evaporated at low temperature (since the boiling point of water at atmospheric pressure is 212 degrees Fahrenheit, is much higher than that of other liquefied gases used in compression machines, viz., 14 degrees Fahrenheit for sulphurous acid, — 13 degrees for methyl chloride, — 31 degrees for ammonia, and — 108 degrees for carbonic acid). This was, in fact, quite impossible with piston pumps and could not be accomplished except by recourse to entirely different apparatus, such as ejectors, which, by reason of the enormous velocities attained by the liquid in them, allow a considerable flow of steam. Yet it has been necessary, in order to obtain the requisite high vacuum or low absolute pressure of 0.12 of an inch of mercury to get a refrigeration to 23 degrees Fahrenheit and less than 0.039 inch to reach 28 degrees, generally to combine with a steam ejector a special water ejector fed by a sort of reversed turbine. These two appliances, which separately would be insufficient, give the desired result when they are coupled in series.

The Westinghouse-Leblanc refrigerating machine permits the refrigerant to be employed more simply than in compression machines. While in the latter apparatus the evaporated refrigerant liquid, such as ammonia, cannot generally be employed directly and serves only to cool a brine, in the Leblanc machine it is the brine which is directly cooled and constitutes the refrigerant liquid. At the same time it is concentrated by the natural action of the vacuum machine. This peculiarity avoids the need of concentrating by heating the brine, which becomes quickly hydrated by contact with the moisture of the air and the substances that are being cooled. Here, on the contrary, it is always necessary to add a certain quantity of water to the heated brine before sending it to be cooled.

When the Leblanc machines were first built, the water vapor removed from the brine was condensed in the water ejector itself. This arrangement was applied only in one installation, in the Gillet Chemical Works, at Lyons, to cool a dye-works product to 46 degrees Fahrenheit only. In all subsequent installations the water vapor removed from the brine has been condensed in a separate mixing or surface condenser, the vacuum pump of which is formed by a liquid ejector. This new arrangement has rendered easily possible the design of powerful refrigerating machines for low temperatures, which would not have been practicable with the simple ejecto-condenser applicable only to small installations for quite high temperatures.

The accompanying illustration is a diagrammatic sketch of a Leblanc refrigerating machine, with a mixing countercurrent condenser, such as that installed at the Bethune mines. All the other installations are of nearly the same type, except that the condenser may be of the surface type. The heated brine coming out of the refrigerator *R* passes to a dilution tank *S D*, where a cock with a float brings fresh water when the level in the tank falls below a certain point. The brine, suitably diluted, is thence drawn up through the pipe *S C* to the top of the evaporator *A*, by reason of the vacuum existing therein. This evaporator is formed of a cylindrical body *B*, carrying at the top a finely perforated plate, through which the heated brine falls in slender jets. Under the influence of the vacuum which prevails in the evaporator, this brine in falling liberates water vapor, which escapes by the annular jacket surrounding the cylindrical body *B* and rises to pass through the short pipe *A E*. At the same time the brine, cooled by con-

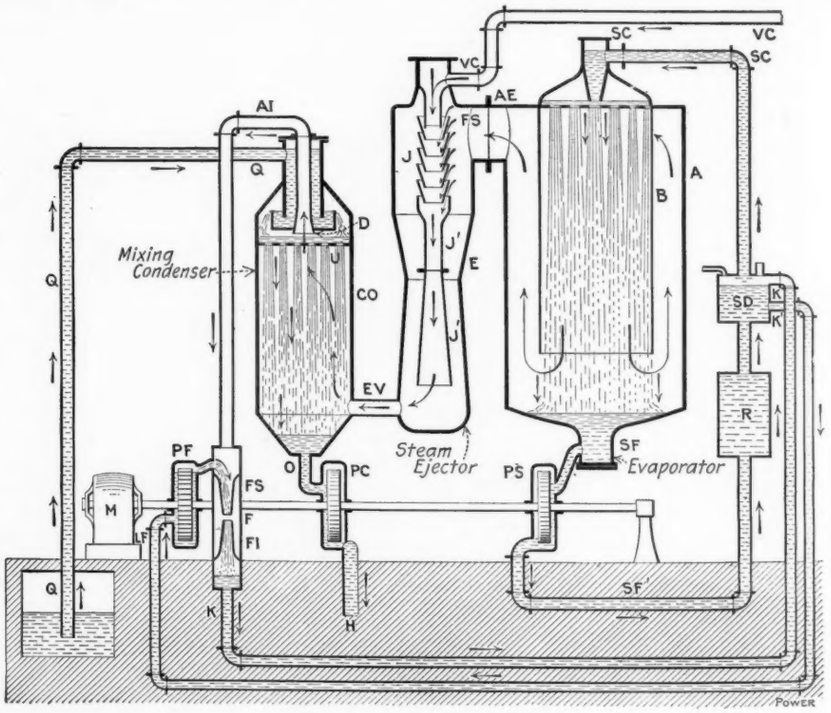


DIAGRAM OF WESTINGHOUSE-LEBLANC WATER REFRIGERATING SYSTEM

*Translated from an article by Ch. Jacquin in *La Technique Moderne*.

centration, falls to the lower part *S F* of the evaporator *A*, where a centrifugal pump *P S* sends it to the refrigerator *K*.

The air and water vapor removed from the brine, at low pressure, enter at *A E* the periphery of the steam ejector *E*, which contains a series of nozzles *J* followed by a converging and diverging cone *J'* into which comes a flow of hot steam from the pipe *V C*, which can be at atmospheric pressure only. The hot steam jet enters the nozzles *J* and draws along with it into the cone *J'* the air and cool vapor coming from the brine. The mixture passes out at the lower part *E V* of the steam ejector and into the lower part of the condenser *C O*, where it is drawn upward by the vacuum exerted in the pipe *A I*. In rising, it meets slender jets of cold water coming from the tube *Q* and spraying through a finely perforated plate *U*. In contact with this water, the water vapor of the mixture condenses and falls with the sprayed water to the bottom *O* of the condenser, where the two combined waters are discharged at *H* by a centrifugal pump *P C*. The air which was contained in the rising gaseous mixture, with the water vapor from the brine, is sucked through the upper central orifice *D* into the pipe *A I*.

The suction is produced in *A I*, at the top of the condenser, by a water ejector *F*, containing a converging cone *F S*, into which is injected a liquid, generally water, at very high velocity, forced by the turbine pump *P F*. The liquid injected into *F S* carries with it, into the diverging cone *F I*, the air sucked from the condenser and falls into *K*.

In the ejecto-condenser machines (corresponding in the figure to a direct communication of the base *E V* of the steam ejector *E* with the top *A I* of the liquid ejector *F*) the ejecto-condenser is fed at *L F* by the water sucked from a well or tank, but it is then necessary to prime it with water under pressure. In the machines with a separate condenser, such as that shown, the turbine pump *P F* is fed with the brine itself coming through *K' L F* from the dilution tank *S D*, and returning there at *K* whenever the level in this brine tank *S D* is to be raised. There is nothing further to consider but the priming of the liquid ejector, which starts work when the pipe *K'* is open. Likewise there is no need of special water for the operation of this ejector, whose speed of circulation is such, and which requires so little liquid that it causes no trouble in the brine tank *S D*.

The liquid ejector *F* gives a constant vacuum, equal to the tension of the water vapor at the temperature of the liquid of condensation, some 15 to 20 millimeters. The steam ejectors *E* have their piping calculated to bring about the vacuum begun by the liquid ejector *F*, so as to obtain in the evaporator *A* a final absolute pressure, variable according to the temperature to which the brine should be cooled; for example, 0.12 inch of mercury when it is desired to reach 23 degrees Fahrenheit, and ¼ inch of mercury when 41 degrees suffices.

The three pumps, *P S* for circulating the brine, *P C* for discharging the condenser and *P F* the pump of the water ejector, all being of centrifugal type, are driven by a single small electric or steam motor *M*.

The Leblanc machine has the advantage of being built only of strong parts, with no valves, etc., subject to rapid wear. The absence of noise is also in certain cases a valuable quality; for example, on the "Suffren," and on the seven large warships of the "Danton" type now in construction, where there is an interesting application of this refrigerating machine for cooling ammunition magazines. The brine cooled in the refrigerating machine serves for cooling to a temperature of a few degrees above 32 degrees Fahrenheit, the air entering an air cooler and circulating in the magazine, thus preventing such rise of temperature of the powder as to cause an explosion.

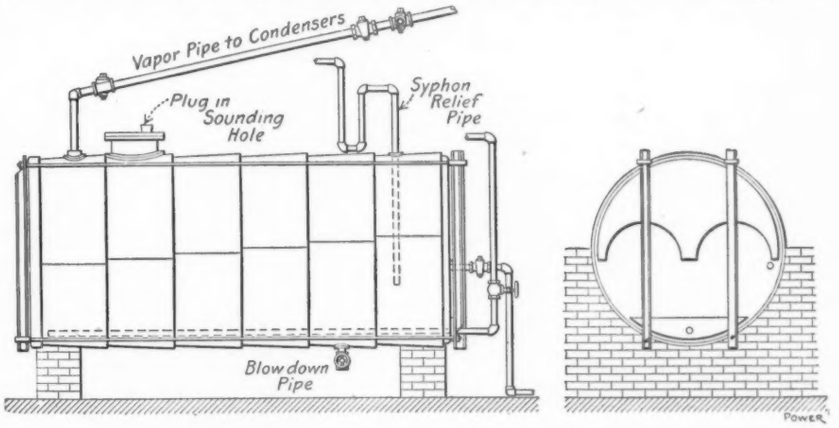
The Westinghouse-Leblanc machine is well adapted to chemical industries where there is no need to cool below the freezing point, its efficiency then being excellent, while for very low temperatures its power and efficiency notably decrease because of the extremely weak tensions which the water vapor then shows. It has recently been applied in the Nanterre factory of the French Glue and Gelatine Company to cool the air used to hasten the viscosity of the gelatine. In this installation, since the brine does not require to be cooled to a low temperature, the evaporation of the water does not need a high vacuum, and a steam ejector alone suffices to produce the vacuum required in the mixing condenser; the liquid ejector and its turbine pump are then unnecessary.

The Leblanc vacuum machine consumes in its condensers a little more water than compression machines require for their cooling, but, when the temperature of refrigeration is not very low, it takes, as motive power employed for driving its pumps, and as steam necessary for its ejectors, a total energy rather less than the mechanical power required for driving a compression machine; and this power is produced economically when the steam of the ejectors, which constitutes the greater part of it, may be derived from the exhaust of steam engines, as is often the case in large works.

Explosion of an Ammonia Still

Another instance in which the necessity for a pressure gage and other suitable fittings was disregarded with disastrous results, is brought out in a recent report of the British Board of Trade.

At the Moorfield Chemical Works, Altham, England, an old Lancashire boiler had long been used as a still for manufacturing liquid ammonia from crude ammoniacal liquor. The boiler was 6 feet 6 inches in diameter by 14 feet 6 inches long, and consisted of six rings, each composed of two ⅜-inch plates. The heads were $\frac{7}{16}$ inch thick and were secured to the shell by means of internal angle irons. Double angle irons were also riveted to the front head and a pair of girders were placed vertically across the outside of each head, their ends being clamped to tie-rods running the entire length of the boiler, as shown in the illustration.



OLD BOILER USED AS AN AMMONIA STILL

A 1½-inch wrought-iron pipe for charging the boiler with ammoniacal liquor and milk of lime, entered the front head as did also a similar pipe for supplying the heating steam. A valve was fitted on each of these pipes and a 1½-inch vapor pipe led from the crown to two condensers. There was a siphon relief pipe, 1½ inches in diameter, which passed through the boiler crown and was connected to an internal pipe, the open end of the siphon being about 3 feet above the top of the boiler and the length of the internal pipe 4½ feet.

A blow-down cock was fitted to the bottom of the boiler and a manhole was

provided at the top, through the cover of which was drilled a ¼-inch hole for sounding purposes; the latter was closed by a wooden plug. The vapor pipe also contained a ¼-inch hole for ascertaining the strength of the gas, and, like the other, this was closed by a wooden plug. No pressure gage or other mountings were fitted.

The method of working the distilling apparatus was as follows: When the boiler was to be charged, the cocks on both branches of the vapor pipe were closed. The ammoniacal liquor was then run in from the settling tank, up to within 3 feet of the top of the boiler, and then about 4 to 6 inches of milk of lime was introduced by means of an injector. The charging cock was then closed and the steam valve opened, admitting steam into the boiler and boiling the liquor.

The gas evolved was led to the condensers, where it was condensed to liquid ammonia. There were two condensers, it being the usual practice to pass the gas to one condenser for 20 hours, one cock being open and the other shut. The cocks were then changed and the gas led to the other condenser, which, after working for another 20 hours, exhausted the charge in the boiler. The spent liquor remaining in the boiler was run off by means of the cock at the bottom of the boiler, after which recharging took place. It required about one hour to run off the spent liquor, and another hour to charge the boiler. It was customary to open one of the outlet cocks on the vapor pipe at the same time as the steam was turned on to the boiler.

At about midnight on the night before the explosion the boiler was due for recharging and, according to custom, the man on duty should have opened the steam valve and the vapor cock, the latter of which he apparently neglected to do. For, about two hours later, a violent explosion occurred, blowing out the front head, the rivets connecting it with the angle-iron ring having been completely sheared off and the tie-rods ruptured. The rear head was also torn at its connection to the shell for about four-fifths of its circumference, and the boiler was projected backward about 2½ feet. The attendant was so severely injured that he died a few hours later.

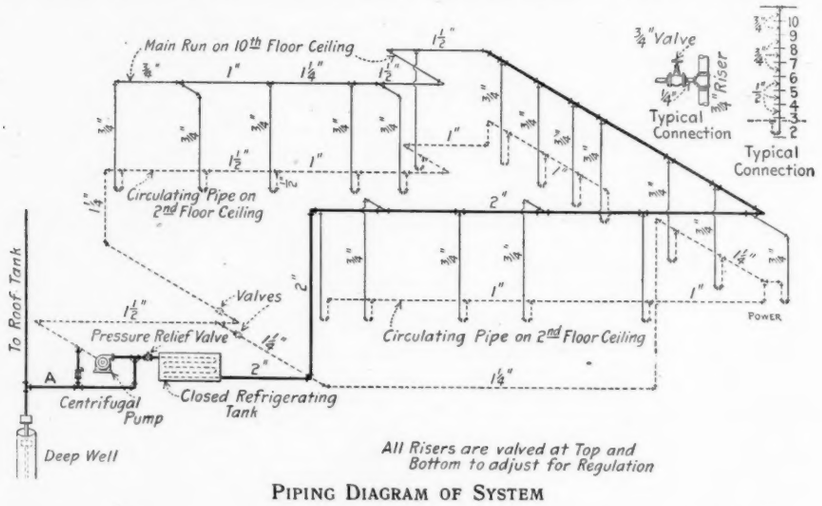
An investigation after the accident showed the relief pipe to be completely choked and as there was no pressure gage nor safety valve attached, an explosion was inevitable.

Air in Ice Water System

By Charles J. Johnson

I inclose herewith a blueprint of an ice-water system that is giving considerable trouble by mixing air with the water, causing it to become milky. As very few people know the real cause of this color, I am troubled with constant complaints.

I have thought out a remedy for this in the following manner. Put an air trap on the supply pipe *A*, or disconnect the line at this point and put in a direct line from the tank. Either one or both can be done, if necessary, but would like to hear from Power readers first.



Piping Diagram of System

Purging the Absorption System

By H. Westergaard

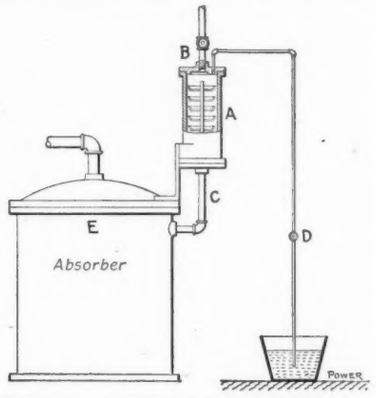
To get the best possible results from an ammonia-absorption system, the foul or permanent gases collecting in the top of the absorber must be drawn off at regular intervals. A purge connection with a shut-off valve is provided at the top of the absorber for this purpose in all installations of this kind, and the usual way to proceed when purging is to submerge the open end of this connection in a pail full of water. Then the purge valve is opened slightly and the gases are allowed to escape through the water.

The permanent gases will rise through the water and escape into the atmosphere, as they are not absorbed by the water. Most of the ammonia vapor which is mixed with these gases is absorbed by the water. This water is generally thrown away and the ammonia absorbed in it lost.

To avoid this loss of ammonia the writer employs the apparatus illustrated herewith.

The poor liquor from the exchanger enters an upright cylinder *A* at *B* and runs down over a number of perforated pans suspended at equal distance through the length of the cylinder. The lower end is connected with the top of the absorber by a pipe *C*. The purge pipe is connected to the top of the cylinder and is provided with a valve. The gases collecting in the space *E* of the absorber flow through pipe *C* and in the cylinder come in contact with weak and cool aqua ammonia, which presents a large surface and rapidly absorbs the ammonia gas present. The foul gases being insoluble under the existent pressure flow to the top of the cylinder and may be removed through the purge pipe.

The apparatus above described has so far proved successful, and it is my belief that it will not only save ammonia but will furnish a lower absorber pressure than would be possible without it. Whether I am right the operation of the plant this summer will show.



Scheme to Avoid Loss of Ammonia

One of the few points of advantage of the absorption system over the other refrigerating systems is that it is better adapted to maintain low temperatures, but it can only accomplish this result if the absorber and other parts of the system are kept free from permanent gases.

Analyses have shown that the foul and permanent gases purged from an absorption system contain besides air some gases which have been formed by the decomposition of ammonia, and practical experience seems to indicate that this decomposition increases with the temperature in the generator or still. It is, therefore, of great importance to provide that part of the plant with an abundance of heating surface, properly distributed so that the temperature of the liquor in the generator can be maintained at a fairly low point when the machine is operating at its maximum capacity.

Spring Meeting Mechanical Engineers

It has been 27 years since the American Society of Mechanical Engineers last met at Pittsburg before the spring meeting of this year, which was held there from May 30 to June 2. The extensive mechanical interests attaching to Pittsburg and the large membership of the society in and about that city justified expectations of an especially profitable gathering which were fulfilled by the event. The attendance was large and the program replete with interest, excellently arranged and admirably carried out.

Those who arrived on Tuesday had an opportunity to inspect the Foundry and Machine Company exhibit installed in connection with the convention of the National Foundrymen's Association, which had taken place the previous week. In the evening an informal reception was held at the Hotel Schenley, during which President E. D. Meier was presented with an engrossed testimonial in commemoration of his seventieth birthday, the presentation being made by J. H. Woodbury, as follows:

"The flight of time is so noiseless that it requires anniversaries to mark its progress, and at a meeting of engineers in Boston a few weeks ago, it was remarked that you would have a notable anniversary on this occasion which ought to be recognized in a manner similar to that of the seventieth birthday of several of your associates and predecessors, and the matter was placed in the hands of a committee of your fellow members from various parts of this country.

"Your career has been indeed a notable one in its facility of doing many things and doing them well.

"In the service of your country in both cavalry and artillery, you became a part of movements of national history. In the reorganization of the militia of your State, you became a force in the maintenance of law and order.

"It is, however, in the greater victories of peace that we have come more closely in touch with your career as an engineer.

"You have been connected with the great cotton industry in making improvements in baling the raw material, in mill construction, and also that of the textile machinery which produces the finished product.

"In the great problems of transportation you have been connected with locomotive practice and railway management.

"The functions of the engineer as an economist have been wrought by yourself in the generation of steam and in the more radical innovations of the internal-combustion engine.

"But this recital of deeds well done is trite in comparison with that of the respectful tribute which we give to your sterling manhood which has endeared yourself to those with whom you have been associated.

"Accept, then, this engrossed testimonial briefly stating our felicitations; and this will be followed in due time by a folio containing the names of those taking part in this testimonial, and we ask you to give sittings to an artist whose portraiture will, I trust, be worthy of the subject."

The sessions were held in the auditorium of the Carnegie Institute, that of Wednesday morning being devoted to the subject of cement.

The Committee on Standardization of the society working in conjunction with a similar committee of the National Association of Master Steam and Hot Water Fitters, presented a schedule of standard-weight flanged fittings and extra-heavy flanged fittings. This schedule will be presented in an early issue.

In the afternoon the visitors were taken to the works of the Universal Portland Cement Company at Universal, and returning a visit was paid to the Westinghouse shops at East Pittsburg.

On Wednesday evening the session at Carnegie Institute was devoted to the machine shop, while the gas-power section held a simultaneous session in one of the halls of the Carnegie Technical Schools. The meeting took the form of a discussion of "Large Gas Power Plants," introduced by descriptions of their plants and relations of their experiences with them by E. A. Maccoun, superintendent of furnaces of the Edgar Thomson Steel Works; R. H. Stevens, mechanical engineer, Homestead Steel Works; A. N. Diehl, superintendent of furnaces, Duquesne Steel Works, and A. L. Hoerr, steam and hydraulic engineer, National Tube Works. Most of the speakers thought that a pause, if not a reaction, had been reached in the rapid development of the large gas engine, and that, even in industries where gas is available as a byproduct, its economic application will be found more limited than has been thought, although H. K. J. Freyn ardently championed the internal-combustion motor and maintained that its present superiority would be emphasized by the increasing cost of fuel. The proceedings of the gas-power section and the discussion will appear in detail in an early issue.

There was also presented at this session a paper describing some of the recent work of the Bureau of Mines, by S. B. Flagg and C. D. Smith. This was illustrated by lantern slides, and described the experiments made with a long combustion chamber having a Murphy stoker at one end, and from which gases are withdrawn each 5 feet of its length for analysis. This furnace and the experiments upon it have been made the subject of a recent bulletin by the Bureau of Mines and will be treated further in an early issue. Reference was also made to experiments now in progress wherein a producer is run at such a high temperature that its capacity is very much increased and by the use of proper fluxes the ash and clinker are melted and drawn off continuously as slag. The temperatures necessary for the formation of liquid slag are very favorable for the production of producer gas and in the tests already made the CO has generally been above 30 per cent. while the CO_2 has been well under 2 per cent. These percentages were obtained, however, with air alone, no steam being used. Frequently 2000 to 2500 cubic feet of gas per square foot of fuel bed have been produced per hour having a heat value of about 115 B.t.u. per cubic foot, thus giving an output of approximately 25 horsepower per square foot of fuel-bed area, and no attempt has been made to operate the producer at its maximum rate.

The local committee had prepared a special pamphlet dealing with the important large gas-engine installations in the vicinity and containing illustrations of those at Carrie Furnaces, the Edgar Thomson Steel Works, the Duquesne Works, the Mesta Manufacturing Company, the Cambria Steel Works at Johnstown, and the National Tube Works, opportunities to visit which were open to the visitors.

The first paper considered Thursday morning was that of Prof. Reid T. Stewart upon "Stresses in Tubes." The author gave the results of some investigations tending to show that the stresses in the wall of a tube exposed to external fluid pressure are of the same character as those in a column having ends fixed in direction.

Using the experimental results obtained in some previous tests upon the collapsing pressures of commercial steel tubing, he derived equivalent column formulas upon the assumption that the circumferential stress in a tubular annulus subjected to external fluid pressure is theoretically the same as that in a straight column with fixed ends, whose length is one-half the mean circumference of the tubular annulus. These formulas are

$$S = 42{,}640 - 127.4\frac{l}{r} \qquad (1)$$

$$S = \frac{708{,}000{,}000}{\left(\frac{l}{r}\right)^2} \qquad (2)$$

where S is the axial load on the column in pounds per square inch; l, the length of the column; and r the least radius of gyration of the column. Formula (1) is applicable only to cases where the

ratio $\frac{l}{r}$ is less than 221 and formula (2) to cases where this ratio is greater than 221.

Next came "The Purchase of Coal," by D. T. Randall. This paper is presented in the columns following this report.

"Energy and Pressure Drop in Compound Steam Turbines," by Prof. F. E. Cardullo gives a graphic method of taking into account the transfer of heat which occurs from the higher to the lower stages by friction, eddy, etc., causing a departure from the condition of constant entropy ordinarily assumed. Professor Peabody submitted a table for the same purpose.

In the "Pressure-Temperature Relations of Saturated Steam," Prof. Lionel S. Marks explains the recent work of Holborn and Bauman and deduces a modification of the Van der Waal formula which expresses the pressure-temperature relations very satisfactorily from 32 degrees to the critical temperature. The values of the pressures derived from this equation have a maximum difference from the best experimental values of about one-tenth of 1 per cent. in the range from 212 to the critical temperature (706.1 degrees Fahrenheit). Below 212 degrees the maximum difference is 0.196 per cent. at 50 degrees corresponding to a pressure of 0.00035 pounds per square inch.

The formula is

$$log.\ p = 10.515354 - 4873.71\ T^{-1} - 0.00405096\ T + 0.000001392964\ T^{2}.$$

"A Pressure Recording Indicator for Punching Machinery" was a description by Prof. G. C. Anthony, of the application of the steam-engine indicator to the punch, obtaining diagrams showing the variation of pressure during the stroke, the maximum pressure for which punches should be designed, the point of maximum stress in the punching of plates, the advantage to be derived from the use of shearing punches, the effect of clearance between punch and die, etc. The lower die rests upon a piston, the pressure of which is communicated to that of the indicator hydraulically. One of the discutants thought that the stress could be taken upon a spring beam which would weigh it more directly.

On Thursday afternoon a portion of the members visited the National Tube Company's works at McKeesport, while the rest were taken by boat up the Monongahela river, calling at McKeesport on the return trip for the others. This excursion proved to be a grateful interim in a rather strenuous program, affording at the same time an opportunity for physical rest and social intercourse.

On Thursday evening a reception and dance was given by the local members in the new ball room of the Hotel Schenley which was hurried to completion for this occasion.

The session of Friday morning, although designated upon the program as a "steel works session," developed considerable interest from the power standpoint through a debate upon the comparative merits of gas engines and turbines for blowing purposes which occurred in the discussion of R. H. Rice's paper upon the "Commercial Application of the Turbo-Compressor, and Reciprocating Blast Furnace Blowing Engines," by Professor W. Trinks. We shall have more to say of this in a subsequent issue. Mr. Rice's paper is presented in this issue.

The concluding paper of the meeting was by Bathold Gerdan, of Düsseldorf, Germany, and George Mesta, and was presented by Herr Gerdan in person. It dealt with steam-hydraulic forging presses of which he is the inventor and which are manufactured in America by the Mesta Machine Works.

On Friday afternoon the visitors had the option of a visit to the Duquesne works of the Carnegie Steel Company or a trip to the Mesta Machine Company's works at West Homestead, both of which excursions were well attended.

A new feature in an American Society of Mechanical Engineers' program was a smoker, given in honor of the visiting societies by the Engineers Society of Western Pennsylvania in the Union Club. George H. Neilson, the orator of the evening, found no difficulty in making light of the rather heavy subject of crucible steel, and numerous speakers, including a local monologuist, together with an excellent quartet, brought out the funny side of engineers and engineering, and wrought the audience up to a condition of good fellowship which made an effective closure of the week's program.

Too much cannot be said of the work of the local committee. Every facility was placed at the command of the visitors for access to the many industrial and engineering attractions of which Pittsburg is the center, and every attention paid to their comfort and convenience. The ladies were kept busy with special receptions, luncheons, drives and visits, and for each of the principal trips an illustrated pamphlet had been prepared with details of the program for that event and descriptions of the principal things to be seen.

Although the selection requires conformation by the council, the expression in favor of Cleveland as the place for the next spring meeting was so unanimous that it is practically certain that the next year's meeting will be held in the "Forest City."

The total output of all the air-compressor plants employed on the Panama Canal work during the year ending June 30, 1910, was 7,227,203,513 cubic feet of free air and the average cost was 4.03 cents per 1000 cubic feet.

The Purchase of Coal*

By D. T. Randall

Large savings may be made in the boiler room along two distinct lines: First, by burning the fuel at the highest practicable efficiency; and, second, by choosing fuel of a character suited to the plant conditions.

The coals of the United States vary widely in character, some being high in fixed carbon and low in moisture, volatile matter and ash, while others are low in fixed carbon and high in other constituents. An analysis reported "as received" represents the composition of the coal just as it is delivered at the laboratory. An analysis reported on the "dry basis" represents the composition of the coal after having been dried for one hour at 105 degrees Centigrade in a special oven. Moisture is an inherent constituent of the coal and an increase in its percentage decreases the heating capacity of a given coal proportionately. This constituent is weighed and paid for on an equal basis with the combustible portion of the coal, and therefore its determination is of importance in ascertaining the value of coal.

The ash in coal is, like moisture, an inert constituent. It may be distributed in small particles in such a way as to make separation from the coal impossible, or some of it may be present in larger pieces, owing to carelessness in mining and preparation. An increased percentage of ash decreases the heating value proportionately and causes additional expense and loss in efficiency due to extra labor required to handle it. The fusibility of the ash governs the amount of clinker that will be formed and consequently some attention should be given to this feature.

The B.t.u. or heating value of coal determines its value as a fuel. When coals of the same character are under consideration the heating value may be taken into account as a correct measure of the value of the coal, but when coals of different character are to be compared, the character of the coal as well as the heating value must be considered.

There is often considerable variation in the quality of coals from the same district; this is due principally to impurities. On account of economy in mining and in marketing coal, it is common practice for one company to operate a number of mines and to ship coal from all of these mines to its customers. It is only rarely that coal is equally good in all the mines and, therefore, the customer will receive some good coal and some inferior coal.

The influence of volatile matter upon the efficiency depends on the design of the furnace. With a poor furnace and indifferent firing, coals containing about

*Abstract of paper read before the American Society of Mechanical Engineers.

18 per cent. volatile matter may give results 10 or 12 per cent. higher than coals containing 30 per cent. or more volatile matter. With furnaces adapted to the kind of coal burned, however, there is little loss of combustible gas.

The size of coal is important in many cases. If it does not coke and is fine, there may be considerable leakage through the grates when burned on stokers with inclined grates or on hand-fired grates at rates that require frequent breaking up of the fuel bed. The size of the coal also affects the economy with which it may be fired. If the coal is too large, more air is admitted than is necessary, and if the fuel bed cannot be increased in thickness to overcome this difficulty, there will be a loss of heat. If the coal is fine and the draft is very strong, some of it will be carried off the grate before it is completely burned. Fine coal which cakes and forms a porous coke may be burned with good efficiency. If the coal does not coke but packs closely on the fuel bed, it is difficult, if not impossible, to secure a uniform air supply at all parts of the bed and the combustion is poor, owing to an excess of air at some points and a lack of air at others.

Fuels considered without reference to any particular equipment may be valued on the basis of their available heating value. It has been found possible to design furnaces to burn almost any fuel with reasonably good efficiency when based upon the available heat of the fuel. This has been accomplished with tan bark, sawdust, lignite and low-grade coals. As a rule, inferior coals can be bought much more cheaply on their heating value than the higher grades of coal and it is to the interest of every consumer to select the coal which will give the greatest amount of heat for a unit cost, provided it can be burned successfully. In many cases it will be profitable to change the equipment so as to burn slack or coals which are below the average quality. It is fully as important to take into account the size and character of coal when automatic stokers are used as when the coal is hand fired.

The methods employed in burning coal are of equal importance with the quality and should be given careful attention. The coal dealer should not be held responsible for results in boiler plants except as influenced by changes in the quality of the coal delivered.

The manner in which a sample of coal is obtained is fully as important as the manner in which it shall be analyzed. It is only fair to both parties concerned that the sample should be obtained in the manner which will secure a small portion which is thoroughly representative of the entire lot.*

*Mr. Randall cited a method of obtaining a sample, identical with that published in the May 23 issue of POWER.

SELECTION OF COAL

The problem of purchasing a supply of fuel for any given plant, so as to obtain coal that is suitable for the equipment in use and one that will deliver the greatest amount of heat to the boiler for each dollar expended, is one which requires experience and an intimate knowledge of the various kinds of equipment for burning coal, and also of the different characteristics of the coals available at reasonable freight rates. The following information should be considered by the engineer in deciding on the best coal for a plant:

a Kind and size of boilers and furnaces;

b Load conditions, average and maximum loads;

c Draft available and how controlled;

d Character of the coals offered or available;

(1) Moisture and its effect on the weight of combustible matter delivered;
(2) Volatile matter and its relation to kind of furnace;
(3) The amount of ash, its fusibility and tendency to clinker;
(4) The amount of sulphur and how combined;
(5) Heating value in B.t.u.;
(6) Coking qualities of the coal;

e Size of the coal;

(1) Relation of the size of coal to the equipment.

SPECIFICATIONS FOR COAL

After it has been decided what kind of coals may be burned successfully in any given plant, it is important that the specifications be so drawn that it will be to the interest of the dealer to deliver the kind of coal which has been established as standard in his proposal and prevent the substitution of lower grades which might be difficult to burn with good results. It is evident that specifications based on the heating value alone will not do this and that there should be some clause making it possible to reject the coal, or to burn it and pay for it at a reduced price if the coal should fall below the requirements.

There has been much said for and against purchasing coal on a guaranteed analysis and, as is often the case, both sides are right but they are really discussing different things. A properly drawn specification protects the dealer who is prepared to furnish good coal in competition with dealers handling inferior coals at the same price. Where these specifications permit the coal contractor to state the analysis of his coal which on acceptance of the bid becomes the standard for the contract, there need be but little variation in the price if the dealer is familiar with the analysis of the coal offered, and if the standard is based on average values the premiums and penalties for the year should practically balance each other. Many dealers have bid on impossible analyses and then blamed the specification plan for their losses.

A properly drawn specification providing for premiums for better coal than that specified, encourages the coal operators to exercise greater care in mining and in picking the coal before shipping, and enables them to secure a return on the cost of such preparation. Most consumers have found that it is not profitable to pay freight on an unnecessary amount of slate and ash in the coal.

The important items in a specification are as follows:

a The amount and character of the coal desired;

b Conditions for delivering the coal;

c A statement regarding the disposition which will be made of the coal if it is outside the limits specified;

d The corrections in price for variations in heating value, ash and sulphur, provided it is advisable to limit the percentages of ash and sulphur in the coal to be delivered;

e A blank form on which the dealer may submit the price and the kind and quality of coal which he proposes to furnish.

This method of purchasing coal has already been adopted by many of the larger and more progressive consumers of coal. Its advantages are so clearly demonstrated to engineers thoroughly experienced in power-house practice that few who are in a position to purchase large quantities of coal are willing to do so without a guarantee as to its quality. With information as to the coal bed, the district and the mine from which the coal will be furnished and the guaranteed analysis, an experienced engineer can make a suitable selection of coal.

A contract based on a guaranteed analysis provides for a definite procedure in settling for variations in the quality of the coal delivered and avoids the necessity of devoting much time to personal arguments and correspondence regarding poor coal. If both the consumer and the seller are familiar with the technical points involved in the sale of coal on a guaranteed analysis, it will prove a fair method by which the purchaser pays according to the value of the coal delivered to him and the dealer is reimbursed for any expense due to better preparation of the coal.

Th' other day I took a walk out inter th' dynamo room an' knocked a hunk of belt dressin' offin' th' pulley. It cum down inter my pipe, but I didn't notice it then. When I got back t' th' ingin' room I could smell er hot box all over th' place, but I cudn't find it an' begun t' get som excited. Jist erbout thet time th' smook got up inter my mouth an I knew kerslap whar th' trouble was.

Commercial Application of the Turbine Turbo-Compressor*

By Richard H. Rice

The General Electric Company recently put in operation at the Oxford Furnace, N. J., plant of the Empire Iron and Steel Company, a turbine-driven air compressor for blowing the blast furnace.

The unit consists of a six-stage compressor operating at a normal speed of 1650 revolutions per minute and driven by a direct-connected four-stage Curtis steam turbine. The design is such that this normal speed produces a blast pressure of 15 pounds per square inch. The unit, however, is designed to regulate the volume of air delivered per minute so as to keep the rate of discharge constant at any value, determined by the furnace superintendent, within its capacity. The construction of this unit, as well as the method of regulation, was given attention in a description of the plant which appeared in the March 7, 1911, issue of Power so that the operation of the unit will be considered only.

Both turbine and compressor attain their best efficiency under similar conditions as regards rotating speed, making the combination a logical and efficient one. Under conditions usually met with in blast-furnace operation involving pressures of blast of 10 to 20 pounds per square inch, the efficiency remains sensibly the same. A curve of efficiency at varying volumes is shown in Fig. 1 and above this has been drawn a curve of speeds and pressures which, taken in connection with the first named curve, shows the variations of efficiency with pressure, at rated volume.

This latter curve shows graphically the variation of pressure with change of speed, which follows the law of squares; that is, doubling the speed gives four times the pressure, etc., from which it will be seen that only moderate changes in speed are necessary to give considerable changes in pressure. It is these changes in speed, increasing or decreasing the blast pressure, which are utilized to maintain a constant rate of flow of air into the furnace, against the varying resistances set up in the tuyeres and furnace by varying furnace conditions; as, for instance, clogging of tuyeres and changes in the size and composition of the charge, temperatures, etc.

The means by which these changes of speed are produced in the manner necessary to keep up a constant rate of influx of air per minute was fully described in the previous article.

At the time this blowing unit was put in operation, it was not expected that the volume of air required by the furnace would be at such a low figure as turned out to be the case, the machine having been designed for a normal volume of 22,500 cubic feet per minute. On putting the machine on the furnace, it was found the volume required was only about 15,000 cubic feet per minute and the pressure corresponding to this volume under furnace conditions ranged from 10 to 12 pounds. Under these conditions, it was found that pulsations were met with in the pressure

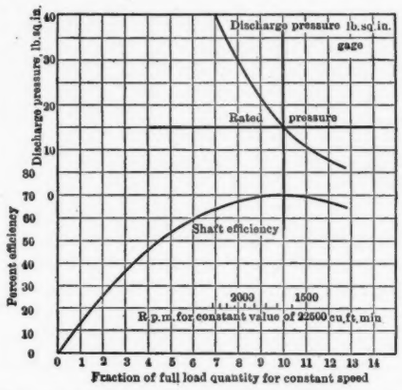

Discharge pressure lb. sq. in. gage
Rated pressure
Shaft efficiency
2000
1500
R.p.m. for constant value of 22500 cu. ft. min
Discharge pressure, lb. sq. in.
Percent efficiency
Fraction of full load quantity for constant speed

Fig. 1. Efficiency and Pressure Curve with Constant-volume Governor

line, this pressure fluctuating about 2 pounds, and in order to overcome this pulsation it was found necessary to throttle the inlet opening. Since this time, a convenient butterfly valve-throttling mechanism has been designed and applied, which is found to eliminate these pulsations without appreciable loss of efficiency.

The pulsations in pressure above noted are an inherent characteristic of all centrifugal blowing apparatus of similar construction, and they occur when the apparatus is operated at loads and pressures widely differing from those for which the apparatus is designed; that is, from normal full volume and pressure. At any given volume they occur at a certain critical pressure and at all higher pressures, but do not occur at lower pressures than the critical. As volume is increased, critical pressure increases also. The critical pressure is slightly affected by the density and the humidity of the air.

Fig. 2 gives the characteristic critical pressure-volume curve of this compressor.

Fig. 3 is the curve of pressure and volumes for this compressor at constant speed.

At the time this was written the blast pressure at Oxford Furnace varied from 10 to 14 pounds during the day with volume constant at 16,000 cubic feet per minute. The speed varied from 1500 to 1600 revolutions per minute. The average steam pressure was 135 pounds.

The figures in Table 1 are taken from a typical station log, showing the variation of pressure and volume during the 24-hour period of operation.

The apparatus used for blowing the furnace before putting this machine into operation consisted of two vertical reciprocating blowing engines built by the I. P. Morris Company, each of the following dimensions: Steam-cylinder diameter, 54 inches; blowing-cylinder diameter, 72 inches; stroke, 72 inches. Blowing-cylinder displacement, 339 cubic feet per revolution each. Maximum speed rating, 30 revolutions per minute each, giving 20,300 cubic feet per minute total displacement. Actual maximum speed, 23 revolutions per minute each, giving 15,000 cubic feet per minute total displacement. The average blast pressure was 8 pounds.

Judging from the revolutions of this engine, it was thought that the volume used was about 14,500 cubic feet. On putting the centrifugal compressor into action, an immediate increase in the

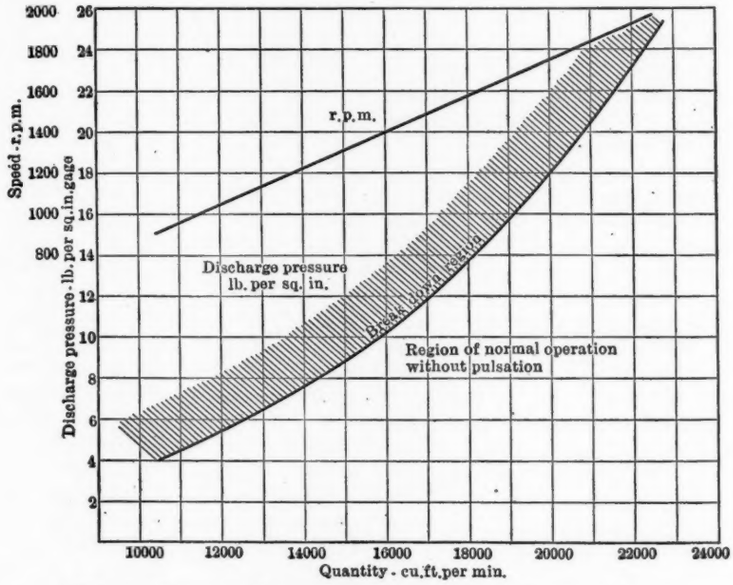

r.p.m.
Discharge pressure lb. per sq. in.
Break down setting
Region of normal operation without pulsation
Speed - r.p.m.
Discharge pressure - lb. per sq. in. gage
Quantity - cu. ft. per min.

Fig. 2. Curve of Breakdown Points from Factory Tests

*Abstract of paper presented before the American Society of Mechanical Engineers.

amount of iron melted by the furnace was experienced. The output went up from an average of 139 tons per 24 hours in February, 1910, to 176 tons in April, 1910, and the iron was found to be of a more uniform character and the operation of the furnace was improved. A gradual increase in the amount of air has since taken place and the corresponding increase in pressure required to force the air through the furnace has been necessary as was to be expected. This increase of air has resulted in an increase in the production of the furnace from 176 tons on starting to the present average of about 190 tons. The machine is now operating with 16,000 cubic feet of air and the production of ore is 185 tons per 24 hours average. It is proposed to continue this increase to 200 tons per 24 hours, the limit of the charging apparatus.

The dimensions of the furnace are as follows: Diameter at bosh, 17 feet 6 inches; at hearth, 11 feet; at top throat, 12 feet; hight from hearth to dumping ring, 80 feet.

The condensing apparatus is of the barometric type. This was described, however, in the March 7 number.

TABLE 1. ENGINE ROOM REPORT, MARCH 17, 1910

EMPIRE IRON & STEEL COMPANY, OXFORD FURNACE, N. J.

Time	Volume, Cu.Ft.	Blast Pressure, Lb.	R.p.m.	Steam Pressure, Lb.	Vacuum, In.
a.m.					
1	15,750	13	1,540	140	24
2	15,750	12.5	1,490	135	25
3	15,750	13.5	1,580	135	25
4	15,750	12	1,510	140	24
5	15,750	13.5	1,530	155	24
6	15,750	13	1,550	150	25
7	15,750	12.5	1,550	150	25
8	15,750	12	1,490	120	h.p.
9	15,750	11.5	1,500	130	h.p.
10	15,750	13.5	1,580	160	26
11	15,750	12.5	1,520	155	26
12	15,750	12.5	1,500	150	26
p.m.					
1	15,750	13	1,530	140	26
2	15,750	12	1,490	150	26
3	15,750	13	1,560	130	26
4	15,750	13	1,560	150	26
5	15,750	11	1,445	145	26
6	15,750	11.5	1,450	130	26
7	15,950	11	1,490	135	26
8	15,750	13	1,510	140	26
9	15,750	12.25	1,500	155	25.5
10	15,750	11	1,383	140	25
11	15,750	11.5	1,410	150	25.5
12	15,750	11.5	1,440	145	25

Made 208 tons of iron in 24 hours.

Owing to the fact that the condensing apparatus is of the barometric type, the further fact that the machine is operating far below its designed capacity and the difficulties involved in making an accurate boiler test to determine the amount of feed water under present conditions, no tests have been made to determine the actual efficiency of the machine. It is, however, furnishing considerably more air than the old machines, as is evidenced by the greatly increased product of the furnace, and is at the same time operating with fewer boilers. Also these boilers are more easily worked than when operating with the engine.

There is great difficulty in making comparisons of the performance of this type of blowing unit with reciprocating types, either steam or gas driven, owing to the absence of actual test figures, since none have been published which permit of accurate and satisfactory comparison. With the results which have been obtained from all sources as to the actual performance of such machines and from actual experience with this machine and its sister machine installed at the Northern Iron Company, in line with tests which have been made in the factory, it seems that the following conclusions are correct in reference to this apparatus as compared with reciprocating engines for blowing blast furnaces:

That the output of the furnace is increased on account of the greater steadiness of operation and more uniform conditions obtaining in the furnace.

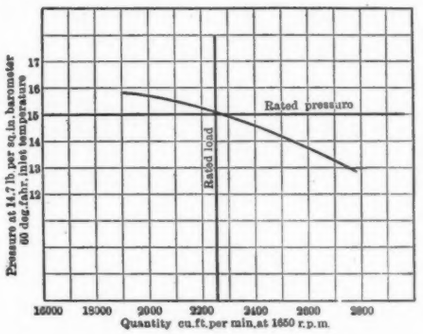


FIG. 3. FACTORY TEST, SHOWING PRESSURE PLOTTED AGAINST QUANTITY OF AIR

That the quality of the product is improved.

That the steam consumption is equal to, or less than, that of the best compound engines blowing similar furnaces.

That the engine-room space occupied is only a fraction of that needed by reciprocating engines, either steam or gas.

Considering all factors, including consumption of fuel; cost of operation, including oil and supplies, attendance, etc.; cost of buildings and foundations, interest on the investment; and cost of maintenance of plant; that the centrifugal compressor is a blowing apparatus which can be operated for a lower net cost than any other means of blowing furnaces.

A power-transmission plant is being erected at Lauchhammer, Germany, designed to generate current for transmission at a pressure of 110,000 volts, which is stated to be the highest voltage used for power transmission in Europe. The current transmitted is three-phase; the generator pressure is 5500 volts, which is transformed up to the transmission voltage by four transformers, each of 6800 kilowatts capacity.

Milwaukee's License Law

That persistent agitation on the part of progressive engineers in all parts of the country for the enactment of license laws and ordinances is not fruitless is proved by the action of the Common Council of Milwaukee, Wis., which recently passed an ordinance making it unlawful for an unlicensed person to have charge of any portion of any steam-power plant exceeding 10 horsepower except locomotives, engines and boilers in the civil service of the city, State or Federal Government and boilers used for heating in which the pressure is less than 15 pounds per square inch.

It is provided that the mayor shall appoint a chief examiner who may select an assistant, the two constituting a board of examiners all of the time of which shall be spent in examinining applicants for license, inspecting boilers and engines and in discharge of such other duties as may be prescribed by the ordinance.

To be eligible for examination an applicant must be 21 years of age; of good moral character; temperate habits; be vouched for in writing by two citizens of Milwaukee and have had not less than two years' experience as a machinist, oiler or fireman in the construction or operation of steam engines or boilers.

Licenses are of three grades and are based on a rating of 12 square feet of heating surface per boiler horsepower. First-class licenses are unlimited as to horsepower; second-class licenses permit the operation of plants up to a capacity of 300 horsepower, while the holder of a third-class license is limited to the operation of 75 horsepower. But any engineer may act as assistant to another holding the next higher grade of license. Special licenses without examination may be issued to engineers covering the plants in which they are employed provided that they have been in charge for the six months next prior to the passing of the ordinance. Transfers of special licenses from one plant to another may be made at the discretion of the board.

All engines, boilers and auxiliary apparatus are directly under the jurisdiction of the board; are subject to periodical inspection, whether insured or not, and all engineers are required to notify the board of any defect in any and every detail. Appeal may be taken from any decision made by the board to a board of arbitration jointly chosen which shall consist of three practical engineers of at least 10 years' experience.

Provision is made for the operation of steam plants by unlicensed men in cases of emergency and many details are left to the discretion of the board of examiners. When not engaged in the actual work of inspection, the board will hold daily sessions from 8 a.m. to 10 p.m. for the purpose of examining applicants for license.

It was the intention of the Common Council to give the city a rational license and inspection ordinance which, administered in the spirit if not in the exact letter, will benefit the engineer, the owner and the public by eliminating the incompetent engine runner and the unsafe boiler.

In one particular the board of examiners is allowed no discretion. It is mandatory that the board see that each and every boiler plant in the city is at all times during its operation in charge of a duly licensed engineer.

Ohio Board of Boiler Rules

Following the example set by Massachusetts the legislature of Ohio has passed a bill creating a Board of Boiler Rules, consisting of the chief examiner of steam engineers, as chairman, and four members appointed by the governor. Of these four it is intended that one shall be an employee of the boiler-using interests, one from the boilermaking interests, one from the boiler-insurance interests and one an operating engineer, but the governor may at his discretion make these four appointments from any class of citizens.

With the exception of boilers of railroad locomotives, portable boilers used in pumping, heating, steaming and drilling in the open field, for water, gas and oil, and portable boilers used for agricultural purposes, and in construction of and repairs to public roads, railroads and bridges, boilers on automobiles, boilers of steam fire engines brought into the State for temporary use in time of emergency, boilers carrying pressures of less than 15 pounds per square inch, which are equipped with safety devices approved by the Board of Boiler Rules and boilers under the jurisdiction of the United States, all boilers in operation in the State must be inspected at intervals not exceeding one year.

Rules for the construction, installation, inspection and operation of boilers, for ascertaining the safe working pressure, for the construction and sizes of safety valves, locations for fusible plugs, and other appurtenances are to be formulated by the board.

Public hearings on complaints, recommendations and for the examinations of inspectors will be held quarterly and at such other times as may be necessary. Changes in the rules may be made after any hearing, such changes being subject to a further hearing which shall have been duly advertised. All changes in the rules which affect the construction of boilers become operative six months after being approved by the governor.

Boilers of special design may be installed by permission of the board if after an examination of the drawings and specifications such boilers are deemed safe. The chief examiner of steam engineers is *ex-officio* chief inspector of steam boilers and is authorized to appoint, with the approval of the governor, an assistant inspector and ten general inspectors for service in the different districts into which the State is divided. He may also appoint as special inspectors employees of any company authorized to conduct boiler insurance and inspection business in the State, provided such employees have passed the examination required by the Board of Boiler Rules.

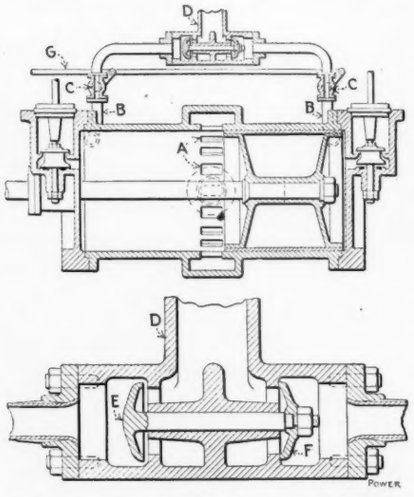
By a system of fees for boiler inspections and for the examinations of applicants for certificates of general boiler inspectors the department will be partially self-supporting.

Punishment by fine or imprisonment or both for the violation of any of the rules of the board by the owner, user or operator of boilers is provided for in the bill which makes the rules of the board operative on January 1, 1912.

In creating the Board of Boiler Rules the legislature of Ohio has closely followed the Massachusetts precedent and it is confidently expected that the same salutary effects will result that have obtained in the latter State in the elevation of the standard in boilermaking.

Stumpf Auxiliary Exhaust Port

In the operation of the uni-directional-flow steam engine of Prof. Johann Stumpf it has been found that the compression at starting and during overload periods is sometimes excessive and to remedy the effect of which an auxiliary exhaust valve has been designed.



STUMPF AUXILIARY EXHAUST VALVE

To each end of the cylinder there is attached a pipe *B* leading to the valve box *D* and controlled by a cock *C*. In the valve box there are two valves, *E* and *F*, mounted on a common spindle.

Under ordinary working conditions the cocks *C C* are closed, but if for any reason it is desired to reduce the compression they may be opened by means of the rod *G*.

With the cocks open and the piston traveling toward the left, steam will be admitted to the valve box and the pressure will close the valve *F* and open *E*. This allows the steam to escape until the compression is high enough to close it or until admission takes place and it is closed by the pressure of steam from the boiler. When the other valve opens the process is repeated at the other end.

PERSONAL

H. J. K. Freyn has resigned his position with the Illinois Steel Company to take charge of the gas-engine department of the Allis-Chalmers Company.

Tom Oakes, who has been identified with the valve interests for the past thirty years, is now connected with the New York office of the Nelson Valve Company.

Reinhard Kunz, who is well and favorably known among the engineers of Wisconsin, has been appointed by the mayor as chief of the board of examiners of engineers for the city of Milwaukee.

SOCIETY NOTES

The Engineers Blue Club of Jersey City will hold its annual outing at Eitners park, Staten Island, on July 9.

On May 26, the American Institute of Steam Boiler Inspectors held a meeting at the United Engineering Societies building in New York City. The major part of the evening was devoted to mechanical topics. J. S. Lane, of the Engineer Company, read a paper on "Combustion and Balanced Draft," which was followed by a lively discussion. F. L. Johnson spoke forcibly on the value of thorough inspections to the engineer in particular and to the public generally. James Winters read a paper on the physical and mental qualifications required to make a successful inspector and pointed out that this field was no place for weaklings. The next meeting of the society will be held at the same place on the last Friday of September, when the regular monthly meetings will begin and be continued throughout the season.

That there is considerable water power in Iceland is denoted by the following announcement: Two English experts have recently visited Iceland in order to survey the large Dettifoss fall, on the river Iökulsa, which is calculated to have a capacity of 60,000 horsepower. Another less known fall, the Vigaberg fall, is estimated to have a capacity of 50,000 horsepower.

New Jersey State N. A. S. E. Convention

The twentieth annual convention of the New Jersey State Association of the National Association of Stationary Engineers took place at Newark, May 2, 3 and 4. There was an exceptionally large attendance of delegates, and at the many sessions considerable important business was transacted. The meetings were all held in the new auditorium.

On Friday at twelve o'clock the exhibition hall in the new auditorium was opened with a short address by Mayor Jacob Haussling. He welcomed the engineers and their guests to Newark and congratulated the convention upon the splendid exhibit of the supplymen. More than seventy booths occupied the main hall, which was neatly decorated, and the display was by far the largest in the history of the New Jersey State Association.

The first session of the delegates was called to order on Friday afternoon, at half past two, by Past State President J. C. Savage, who welcomed the delegates and their friends to the city. Mr. Savage then introduced Harry D. Cozens, one of the organizers of the national association and its first national president, who spoke interestingly of his past experience in the National Association of Stationary Engineers, and concluded his remarks by congratulating the New Jersey State Association upon its progress. It was in the engine room of Mr. Cozens, in the court house at Providence, R. I., in the year 1879, that the National Association of Stationary Engineers was organized. He is now chief engineer of the court house at Newark, N. J. After the appointment of the necessary committees, the several reports were read and adopted, the secretary's report showing the organization to be in a healthy financial condition.

EXHIBIT HALL AT NEW JERSEY STATE CONVENTION

On Friday evening a most enjoyable entertainment was given in the exhibition hall, in which the "Bunch" participated. The program was arranged by Frank Martin.

On Saturday evening a banquet was given at the Continental hotel, which was largely attended by the ladies. F. L. Johnson officiated as toastmaster and introduced the following gentlemen, who made brief and instructive addresses: John H. Donnelly, president of the common council; W. J. Reynolds, past national president; Edward H. Kearney, national vice-president; E. W. Sears, State president; Assemblyman Michael J. McGowan; Joseph F. Carney, past national president; A. L. Case, State deputy; John J. Callahan, past State president. The speeches were interspersed with vocal and instrumental music.

At the Sunday morning session the delegates listened to an able address by National Vice-President Edward H. Kearney, after which the officers for the ensuing year were elected as follows: Edward W. Sears, Newark No. 3, past president; William Krouse, Passaic No. 11, president; Martin J. Hickey, Jersey No. 1, vice-president; Charles Somers, Hoboken No. 5, treasurer; Thomas A. Brown, Newark No. 3, secretary; Thomas J. MacMoran, Paterson No. 2, doorkeeper; Thomas Heath, Elizabeth No. 14, conductor; A. L. Case, Plainfield No. 12, chairman of license committee.

THE NEW JERSEY DELEGATION TO THE STATE CONVENTION

Newark was again chosen as the place for holding the next annual meeting.

The following firms had exhibits:

Acheson Graphite Company, American Steam Gauge and Valve Manufacturing Company, V. D. Anderson Company, Ashton Valve Company, Cling-Surface Company, Couse & Bolten, Crandall Packing Company, James W. Crane, Crane Company, Cryer Return Line System Company, M. T. Davidson Company, Dearborn Drug and Chemical Works, R. & J. Dick, Dixon Cascade Pump Company, Engineers Blue Club of Jersey City, Garlock Packing Company, Greene, Tweed & Co., Greenpoint Fire Brick Manufacturing Company, Griscom-Spencer Company, Hampson & Marks (American Engine Company), Harrison Safety Boiler Works, Hewes & Phillips Iron Works, Home Rubber Company, Homestead Valve Manufacturing Company, Iron Works Company, Jefferson Union Company, Jenkins Brothers, The Henry Johnson Company, E. Keeler Company, Kennedy Valve Manufacturing Company, Keystone Lubricating Company, Lagonda Manufacturing Company, Jacob Levi Company, Lippincott Steam Specialty and Supply Company, Ludlow & Squier, Lunkenheimer Company, McLeod & Henry Company, W. B. McVicker Company, Macknet & Doremus Company, Morehead Manufacturing Company, Mutual Supply Company, Nathan Manufacturing Company, National Oil and Supply Company, Nelson Valve Company, Newark Brush and Scraper Company, New York Lubricating Oil Company, New York Belting and Packing Company, Norben Oil and Supply Company, Ohio Blower Company, Otis Elevator Company, Peerless Rubber Manufacturing Company, Philadelphia Grease Manufacturing Company, William S. Pitts Company, William Powell Company, POWER, Clement Restein Company, John A. Roebling's Sons Company, David C. Seymour, W. S. Sheppard, Simmons Pipe Bending Works, Millard F. Smith, C. E. Squires Company, Standard Oil Company, Standard Regulator Company, Strong, Carlisle & Hammond Company, Under-Feed Stoker Company of America, H. B. Underwood & Co., C. Yingling & Son.

Kentucky State N. A. S. E. Convention

After opening the ninth annual convention of the Kentucky State National Association of Stationary Engineers with prayer by the Rev. J. H. Young, C. E. Fertig, chairman of the convention committee, introduced Mayor W. O. Head, of Louisville, who delivered a warm address of welcome. Frederick L. Ray, State president, followed with the president's annual address, after which R. W. Brown, secretary of the Louisville Convention and Publicity League, spoke, his subject being "Our City." He enlarged upon the beauties and advantages of Louisville as a commercial, residence and convention center and greatly impressed the visitors with the hospitable words of welcome so characteristic of the native Kentuckian. Response was made by Osborn Monnett, of POWER.

F. W. Raven, national secretary, then spoke on "Our Order," outlining its aims and purposes and explaining to the mayor and visitors the high ideals which actuate the association in all its affairs. At the close of the morning session, W. L. Osborne, of Chicago, formally opened the exhibit with a few words of greeting to the delegates.

Owensboro was chosen as the place of next meeting, the new officers being as follows: John H. Oelze, of Owensboro, president; J. L. Shrode, of Hopkinsville, vice-president; J. L. Harpole, of Hopkinsville, secretary; Edward Kockenrath, of Louisville, treasurer; C. Carroll, of Louisville, conductor, and William Cummings, of Henderson, doorkeeper.

A smoker, tendered by the Central States Exhibitors' Association, was a social feature of the meeting, while on Saturday afternoon, after lunch at the Willard hotel, as guests of the Louisville Convention and Publicity League, the delegates and visitors were taken for an automobile ride, visiting the Louisville Lighting Company, the Louisville Railway Company power house and Cherokee park, this also being through the courtesy of the public-spirited citizens.

The meeting came to a close with the annual moonlight excursion on the Ohio river, given by Louisville National Association of Stationary Engineers association No. 1, a special invitation being extended to the visitors.

Exhibitors at the convention were as follows: Ahrens & Ott, Louisville, Ky.; V. D. Anderson & Co., Cleveland, O.; Andrew Cowan & Co., Louisville, Ky.; James Clark, Jr., Electric Company, Louisville, Ky.; Crandall Packing Company, Palmyra, N. Y.; Dearborn Drug and Chemical Works, Chicago, Ill.; Garlock Packing Company, Palmyra, N. Y.; United States Graphite Company, Saginaw, Mich.; Greene, Tweed & Co., New York City; Hawk-Eye Compound Company, Chicago, Ill.; Hills-McCanna Company, Chicago, Ill.; Home Rubber Company, Trenton, N. J.; Jenkins Brothers, New York City; H. W. Johns-Manville Company, Milwaukee, Wis.; Kentucky Consumer's Oil Company, Louisville, Ky.; Laile Company, Louisville, Ky.; Lunkenheimer Company, Cincinnati, O.; Lyons Boiler Works, De Pere, Wis.; Moran Flexible Steam Joint Company, Louisville, Ky.; E. D. Morton & Co., Louisville, Ky.; *National Engineer,* Chicago, Ill.; National Smoke Prevention Company, Louisville, Ky.; W. H. Neil Company, Louisville, Ky.; Osborne High-Pressure Joint and Valve Company, Chicago, Ill.; William Powell Company, Cincinnati, O.; POWER, New York City; *Practical Engineer,* Chicago, Ill.; J. J. Reilly Manufacturing Company, Louisville, Ky.; Standard Oil Company, Louisville, Ky.; Sterling Boiler Compound Company, Louisville, Ky.; Charles C. Stoll Oil Company, Louisville, Ky.; Henry Vogt Machine Company, Louisville, Ky.; Wickes Boiler Company, Saginaw, Mich.

GROUP OF KENTUCKY ENGINEERS AT THE N. A. S. E. STATE CONVENTION

The installation of a large electric-power station at Vemark, in the province of Telemarken, Norway, was started during the early part of May, the Rjukanfos, or Foaming, falls supplying the power for the machinery. This fall, which is one of the magnificent sights of Norway, has been changed so that now there is a straight drop of about 400 feet, where previously the drop was 800 feet. By this means 145,000 horsepower was made available.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

HERE is an interesting letter we received the other day from one of our subscription men in the field:

Cleveland, Ohio,
May 24, 1911.

POWER,
New York.

Gentlemen:—Mr. David Melville, engineer of South High School, Collingwood, Ohio, whose subscription I secured last year and who has just renewed, says POWER is worth many times the subscription price to him.

He saw in POWER the ad. of a boiler tube cleaner, cut out the ad. and made a request to the Board of Education for the article, got it and it gives complete satisfaction.

He saw an article in POWER in reference to repacking asbestos packed blow-off cocks, acted upon it and it has proved entirely satisfactory. Heretofore when repacking was necessary the habit has been to remove the cocks and send them to Buffalo to the makers to be repacked. The saving is: time, expressage both ways and cost of repacking. This new method has been adopted by all the schools in Cleveland.

In the South High School, a year ago, all pipes were exposed in the basement. He read in POWER about the saving in heat (which was not needed in the basement) by covering the pipes with asbestos and prevailed upon the "powers that be" to have the work done. Now the basement is cool and he has demonstrated the wisdom of incurring the expense by the difference in the coal bill.

He also read in POWER a suggestion in reference to using fresh air in the boiler room when heating the building instead of using the air already in the building and he finds it a great improvement.

I give these comments as they came from him for what they may be worth.

Respectfully,
V. W. Johnson.

The point we would make is that here is an engineer who is getting all the value he can from his technical paper. He reads every number carefully—reading matter and advertisements—and when he finds a new article, device or method that will get better results for his employers he sees that it is installed.

It is good education to read the ads.—it is good business to act on them—to buy advertised goods.

This engineer reads his POWER *profitably*—do you?

Water Power in Sweden

It is reported by Consul Stuart J. Fuller, of Gothenburg, in the *Daily Consular and Trade Reports* that a considerable increase was made during 1910 in the amount of water power utilized for the generation of electricity; 21 new power stations, representing an aggregate of 103,530 horsepower, were completed. Of this amount, 40,000 horsepower is represented by the state installation at Trollhatten, in the Gothenburg consular district, already the seat of extensive electric plants. The remaining 63,530 horsepower is represented by 20 private plants located in various parts of Sweden. It is stated that new installations now under construction will add 115,000 horsepower to that which was available January 1, 1911. Of this amount the government station at Porjus will produce 50,000 horsepower and seven private plants the remainder. Five older stations, representing 7650 horsepower, were rebuilt in 1910.

BUSINESS ITEMS

The George M. Newhall Engineering Company, of Philadelphia, has been requested to furnish one of its Vance steam traps for demonstration before the classes at the Annapolis naval academy.

The Hooven, Owens, Rentschler Company, Hamilton, Ohio, has secured the necessary letter patents, and is now building sugar-mill machinery. The cane mills are of the Delbert triangular housing pattern and the cane crushers of the Pre-Miller type.

The Goulds Manufacturing Company, of Seneca Falls, N. Y., is about to build four large additions to the No. 2 plant, in which will be housed the part of the works known as the No. 1 plant, part of which must be torn down to make way for the new barge canal. The new buildings will be parallel with the foundry buildings. A one-story storage building for rough castings is completed. This building is 240 feet by 60 feet and of mill construction. Two machine shops, 300x 100 feet, will parallel the storage building. They will be of steel frame and brick construction and about 70 per cent. of the wall surfaces will be glass. South of the two machine shops a four-story warehouse 240x60 feet will be built. These will be reinforced concrete and on the south side there will be a loading platform. The New York Central will build two additional switches along the warehouse. All the new buildings will be lighted with tungsten clusters and will be heated and ventilated by the hot-blast system. All the equipment of the machine shops will be motor driven. By November 1 the buildings will be ready for use.

NEW EQUIPMENT

Milan, Mo., voted to construct waterworks.

West Brookfield, Mass., will install a waterworks system.

H. B. Ives, New Haven, Conn., will install a boiler and engine.

Simon & Stewart are erecting a power plant at Cornell, Wis.

Leviseur & Co., Salem, Mass., will install boiler, engine and pumps.

F. L. Hervey & Co., Fall River, Mass., will install a boiler and engine.

Edgefield, S. C., voted to issue $15,000 bonds for an electric power plant.

North Bay, Ont., will spend $100,000 for new waterworks machinery.

Charlotte, N. C., will vote on issuance of $350,000 bonds for waterworks.

The Gem City Market, Mesa, Ariz., will build a new refrigerating plant.

Webster City, Iowa, will erect a new municipal electric-light and power plant.

Moosejaw, Sask., will spend $40,000 for additional electric-lighting machinery.

E. M. Archibald, Nictaux Falls, N. S., will build a power plant to cost $100,000.

The East Palestine (Ohio) Pottery Company will add a 100-kilowatt generator.

The Municipal Gas Company, Albany, N. Y., will enlarge its plant on Trinity place.

The council, Henry, S. D., is arranging for the installation of a waterworks system.

Pendleton, Ore., has voted $200,000 bonds for the construction of a waterworks system.

Bedford, Ohio, will vote on the issuance of $45,000 bonds for water and sewer systems.

The Lawton Mill Company, Plainfield, Conn., will install a steam electric power plant.

W. B. Walker & Sons will install a cold-storage plant at Austin, Tex., to cost about $75,000.

Cleveland, Ohio, will erect a high-pressure pumping station. A. B. Lea, public service director.

The village of Salem, N. Y., has granted franchise to Frank A. Hill to install a waterworks system.

The city council, Newton, Iowa, has decided to erect a new municipal electric-light and power plant.

The Central Ice Company, Boston, Mass., will erect a new artificial ice plant, boiler and engine house.

The city council Decatur, Ala., has under consideration the question of a municipal electric-light plant.

H. E. Graw & Co. will erect a boiler and engine house at Hancock and Turner streets, Philadelphia, Penn.

The St. Johnsbury (Vt.) Electric Company will install two hydroelectric units of about 200 kilowatts.

The Boston Cold Storage and Terminal Company will build a new cold-storage plant at East Boston, Mass.

The power plant of the Mountain Ice Company, at Stroudsburg, Penn., was destroyed by fire. Loss, $40,000.

D. M. Scott, Greenspring, Ohio, has been granted a franchise to operate an electrical plant for light and power.

The Philadelphia Suburban Gas and Electric Light Company will build a new power plant at Pottstown, Penn.

A. E. Hammond, Madras, Ore., is planning the erection of an electric-light and power plant. Franchise has been granted.

Power-plant equipment will be required in the new building to be erected by the Mt. Zion Hospital Association, San Francisco, Cal.

The Syracuse (N. Y.) Rapid Transit Company contemplates the erection of two additional transformer stations to cost $158,000.

The Ohio Building Safety Vault Company, 509 Wabash avenue, Chicago, Ill., is in the market for an electrically driven house pump.

The Indian Valley Light and Power Company, Greenville, Cal., will build a new 25,000-horsepower power plant on the Feather river.

McKenzie, Tenn., will open bids July 1 for the construction of an electric-light plant. C. H. Jenks, St. Louis, Mo., engineer in charge.

The Southwestern Traction and Power Company will erect a power house at New Iberia, La. F. W. Crosby, New Orleans, is president.

Bids will be received until June 27, by Jacob J. Jones, city clerk, Bridgeton, N. J., for the construction of pumping station and water filtration works.

The Uhrichsville (Ohio) Ice Company has been incorporated with $25,000 capital to manufacture ice, by F. E. Cooper, Geo. S. Evans, J. E. Groves.

The Pacific States Electric Company, Portland, Ore., has purchased the electric-light plant of H. W. Fellows, at Goldendale, Wash., and will improve same.

Engine and generator will be installed in the new building to be erected on the Newburg State Hospital grounds, at Newburg, a suburb of Cleveland; C. H. Clark, superintendent.

The Syracuse (N. Y.) Lighting Company will issue $456,000 bonds for extending and improving its gas and electric departments, including new stations at East Syracuse, Manlius and Jamesville.

A syndicate composed of A. S. W. White and Ralph Aldrich, of Detroit, Mich., and I. W. Durfee, Chicago, will erect a power plant on the Miami river, at Woodsdale, near Hamilton, Ohio, to have a capacity of 20,000,000 kilowatt-hours per annum.

NEW CATALOGS

Federal Metallic Packing Company, Boston, Mass. Folder. Metallic packings. Illustrated.

Vulcan Soot Cleaner Company, Du Bois, Penn. Catalog. Vulcan soot cleaner. Illustrated, 32 pages, 6x9 inches.

Yarnall-Waring Company, 1109 Locust street, Philadelphia, Penn. Circular. "Power Plant Economy." Simplex seatless blow-off valve. Illustrated.

Frank L. Patterson & Co., 26 Cortlandt street, New York. Pamphlet. "Guaranteed Coal Saving." Patterson-Berryman feedwater heater and purifier. Illustrated, 48 pages, 6x9 inches.

Fort Wayne Electric Works, Fort Wayne, Ind. Bulletin No. 1128. Multiphase induction motors. Illustrated, 32 pages, 8x10½ inches. Bulletin No. 1129. Multiphase induction watt-hour meter, type K3. Illustrated, 12 pages, 8x10½ inches.

De La Vergne Machine Company, Refrigeration department, foot East One Hundred and Thirty-eighth street, New York. Bulletin No. 110. Clearance in the Ammonia Compressor—A Discovery. Illustrated, 8 pages, 8x10½ inches.

General Electric Company, Schenectady, N. J. Bulletin No. 4826. General Electric water-flow meter. Illustrated, 6 pages, 8x10½ inches. Bulletin No. 4827. General Electric air-flow meter. Illustrated, 10 pages, 8x10½ inches.

HELP WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

Wanted—A first class belt salesman to sell belting for a large manufacturer. Address full particulars to "Belting," Care POWER.

ENGINEERS to solicit orders for the Rolin patent adjustable grate bar. Apply Standard Grate Co., Heed Bldg., Philadelphia, Penn.

WANTED—Thoroughly competent steam specialty salesman; one that can sell high-grade goods. Address "M. M. Co.," POWER.

AN ENGINEER in each town to sell the best rocking grate for steam boilers. Write

Martin Grate Co., 281 Dearborn Street, Chicago.

AGENTS WANTED for first-class steam specialty in use throughout United States. Address C. S. Wood, 410 S. 15th St., Philadelphia, Penn.

SALESMAN calling at power plants to handle as a side line superior packing for steam, different from the rest and better. Nugget Packing Co., 185 Summer St., Boston, Mass.

WANTED—First class firemen, 12-hour shift, 6 days, $70 or $75 per month with premiums on coal economy; must be capable men; we have no place for coal heavers. Box 448, POWER.

WANTED—An engineer in each city as agent for a high class water-back Scotch boiler, the most economical steam generator known to the trade. Kingsford Foundry & Machine Works, Oswego, N. Y.

WANTED—Gas engineer; man familiar with Westinghouse horizontal engines, capable of taking charge of plant equipped with a 500-kilowatt horizontal and a 100-kilowatt vertical gas engine, located in central New York on railroad; large house electrically lighted; rent free to married man; state age, experience and salary wanted. Address Room 22, No. 115 Genesee St., Utica, N. Y.

SITUATIONS WANTED

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

POSITION WANTED by a competent suction gas man as operator, own repairing; extensive experience on single and multiple cylinder plants; references furnished. Box 447, POWER.

MARRIED MAN wishes employment in or around New York City as an engineer, fireman or oiler; have had two years' mining experience and can furnish necessary recommendation from previous employer. Box 450, POWER.

TECHNICAL MAN, 34, married, 13 years' experience, power, light, telephone, construction and operation, want connection as electrical engineer or superintendent, light or power plant; good business ability; prefer West or South; would consider foreign country. Box 433, POWER.

MISCELLANEOUS

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

Formula for excellent remedy for hot crank pin brasses. Send 50c. Box 43, Coffeyville, Kan.

PATENTS. C. L. Parker, Patent Attorney, ex-examiner Patent Office, 904 G St., Washington, D. C. Write for Inventor's Handbook.

PATENTABLE IDEAS WANTED—Manufacturers want Owen patents. Send for three free books. R. B. Owen, 43 Owen Bldg., Washington, D. C.

The Vulcan Soot Cleaner offers an exceptional opportunity for power specialty salesmen. For further particulars address G. L. Simonds & Co., 802 Steinway Bldg., Chicago, Ill.

EVERY ENGINEER should be posted regarding the new system of vacuum heating installed without payment of royalty; I have valuable information; write today. T. L. Reeder, 1417 W. Jackson Blvd., Chicago, Ill.

YOUR SALES AGENCY WANTED—Experienced mechanical and electrical sales-engineer wants eastern Pennsylvania agency; boilers, engines, generators, pumps, blowers, heating, steam or electric specialties; intimate acquaintance with architects, engineers, contractors, etc.; 16 years in territory. Box 385, Care E. C. Rahme, 38 N. Broad St., Philadelphia, Pa.

FOR SALE

Advertisements under this head are inserted for 25 cents per line. About six words make a line.

FOR SALE—One Cooper Corliss engine, 14—24x42 cross compound; in good order; now running; can be seen any day. John Boyle Co., Jersey City, N. J.

FOR SALE—20x48 Wheelock engine and two 72"x18' high pressure tubular boilers in good condition cheap. Address "Engineer," Box 2, Station A, Cincinnati, Ohio.

FOR SALE—For immediate delivery, two Cooper Corliss engines, direct connected to Westinghouse direct-current, 125-volt generators, 100 r.p.m., sizes 100 to 200 kilowatts; also one Westinghouse vertical direct connected unit 25 kilowatt capacity, 125 volts, direct current. Box 449, POWER.

FOR SALE—One compound Reynolds Corliss engine, high pressure cylinder 32 inches, low pressure 60 inches, stroke 60, 1200 horsepower at 100 pounds pressure, 70 revolutions per minute, flywheel diameter 20 feet, face 56 inches, built in sections; shaft length 16 feet diameter in wheel 16 inches, single eccentric. Box 434, POWER.

ALPHABETICAL INDEX TO ADVERTISERS

	PAGE
Air-Flex Co.	106
Albany Lubricating Co.	76
Alberger Condenser Co.	95
Alberger Gas Engine Co.	112
Allis-Chalmers Co.	84
American District Steam Co.	109
American Eng. Co.	113
American Mfg. Co.	98
American Metal Hose Co.	98
American School of Correspondence	73
American Ship Windlass Co.	91
American Steam Gauge and Valve Mfg. Co.	60 and 61
Ames Iron Works	114
Anderson Co., V. D.	78
Appleby Co., George	83
Armstrong Mfg. Co.	88
Ashton Valve Co.	86
Austin Separator Co.	78
Babcock & Wilcox Co.	104
Baker Valve Co.	110
Ball & Wood Co.	116
Ball Engine Co.	115
Baragwanath & Son, Wm.	96
Barnes Co., W. F. & John	83
Bayer Steam Soot Blower Co.	105
Beggs & Co., James	97
Betson Plastic Fire Brick Co.	106
Bignall & Keeler Mfg. Co.	88
Blake & Knowles Steam Pump Works	96
Bogart Gas Power Engineering Co.	110
Borden Co., The	88
Bristol Co.	4th cover
Bruce-Macbeth Engine Co.	72
Buckeye Engine Co.	114
Buffalo Forge Co.	85
Builders Iron Foundry	102
Burt Mfg. Co.	18
Cade & Knapp	73
Cameron Steam Pump Works, A. S.	94
Cancos Mfg. Co.	81
Casey-Hedges Co.	104
Chaplin-Fulton Mfg. Co., The	106
Chapman Valve Mfg. Co.	89
Chesterton Co., A. W.	84
Cling-Surface Co.	99
Columbian Rope Co.	98
Conard, Thos. P.	74
Consolidation Coal Co.	70
Cooper Co., C. & G.	116
Corliss Chemical Co.	106
Crosby Steam Gage & Valve Co.	89
Curtis & Curtis Co.	85
Dart Mfg. Co., E. M.	88
Dearborn Drug & Chemical Works	5
Deming Co.	95
Detroit Lubricator Co.	83
Diamond Rubber Co.	81
Dixon Crucible Co., Jos.	83
Du Bois Iron Works	110
Elliott Co.	7
Epping-Carpenter Co.	95
Eureka Packing Co.	68
Fitchburg Steam Engine Co.	116
Flexible Steel Lacing Co.	84
Foos Gas Engine Co.	116
Garlock Packing Co.	9
General Electric Co.	101
Golden-Anderson Valve Specialty Co.	85
Goulds Mfg. Co.	94
Green Engineering Co.	92
Greene, Tweed & Co.,	82 and 4th cover
Griffith & Wedge Co.	114
Griscom-Spencer Co.	1st cover
Hammel Oil Burner Co.	90
Harbison-Walker Refractories Co.	107
Harris Steam Engine Co., W. A.	113
Harrisburg Fdry. and Mach. Works	114
Harrison Safety Boiler Wks.	63
Heine Safety Boiler Co.	105
Hewes & Phillips Iron Wks.	116
Hoffman, Geo. W.	98
Holyoke Steam Boiler Works, Inc.	72
Homestead Valve Mfg. Co.	89
Hooven, Owens, Rentschler Co.	113
Hoppes Mfg. Co.	96
Hughson Steam Specialty Co.	89
Huyette Co., Inc., Paul B.	88
Ide & Sons, A. L.	116
Ingersoll-Rand Co.	98
International Corr. Schools	67
Jamieson & Co., M. W.	95
Jefferson Union Co.	10
Jeffrey Mfg. Co., The	95
Jenkins Bros.	65
Johns-Manville Co., H. W.	73
Johnson Rule Mfg. Co., E. P.	94
Keeler Co., E.	105
Kellogg Co., The M. W.	78
Keystone Lubricating Co.	3
Kingsford Fdry. & Mach. Wks.	105
Kinkead Mfg. Co.	96
Lagonda Mfg. Co.	3d cover
Laidlaw-Dunn-Gordon Co.	109
Liberty Mfg. Co.	7
Long Grate Bar Co.	90
Lunkenheimer Co.	4
Lytton Mfg. Corporation	71
McClave-Brooks Co.	14
McGraw-Hill Book Co.	108
McIntosh, Seymour & Co.	116
McLeod & Henry Co.	106
Machinery Brokerage Co.	74
Magnolia Metal Co.	110
Manzel Bros. Co.	83
Mason Regulator Co.	86
Mellor Furnace Engr. Co.	72
Minneapolis Steel & Mach. Co.	110
Monarch Valve & Mfg. Co.	89
Morehead Mfg. Co.	82
Morrin Climax Boiler Co.	104
Morse Chain Co.	118
Murphy Iron Works	90
Nashua Machine Co.	78
National Pipe Bending Co.	96
National Tube Co.	89
Neemes Bros.	92
Nelson Valve Co.	87
New Bedford Valve Mfg. Co.	85
New Process Raw Hide Co.	98
New York & New Jersey Lubricant Co.	83
New York Belting & Packing Co., Ltd.	12
New York Edison Co.	112
Newhall Engr. Co., Geo. M.	77
Northern Equipment Co.	72
Ohio Blower Co.	93
Oil City Boiler Works.	105
Oil Well Supply Co.	104
Open Coil Heater & Purifier Co.	96
Parson Mfg. Co.	91
Patterson & Co., Frank L.	74
Peerless Rubber Mfg. Co.	8
Penberthy Injector Co.	13
Pennsylvania Coal & Coke Co.	90
Pennsylvania Flexible Metallic Tubing Co.	75
Perfection Grate Co.	92
Perkins Co., Jno. B.	88
Pierce Co., Wm. B.	2d cover
Pittsburgh Valve, Fdry. and Construction Co.	89
Power Specialty Co.	81
Precision Instrument Co.	103
Providence Engineering Wks.	116
Quaker City Rubber Co.	80
Quimby, Inc., Wm. E.	94
Reliance Gauge Column Co.	79
Remington Oil Eng. Co., The	109
Richardson-Phenix Co.	83
Ridgway Dynamo and Engine Co.	113
Robb Engineering Co., Ltd.	104
Robertson & Sons, Jas. L.	69
Rogers Co., H. A.	94
Rollins Engine Co.	117
Rooksby & Co., E. J.	109
"S-C" Regulator Co.	4th cover
St. John, G. C.	84
Salamander Grate Bar Co.	92
Scaife & Sons Co., Wm. B.	104
Schade Valve Mfg. Co.	85
Schieren Co., Chas. A.	98
Schuchardt & Schutte	84
Schutte & Koerting Co.	95, 102
Simonds & Co., G. L.	103
Skinner Engine Co.	114
Smith, Rudy & Co.	103
Smooth-On Mfg. Co.	6
Squires Co., C. E.	79
Standard Grate Co.	92
Star Brass Mfg. Co.	111
Starrett Co., L. S.	90
Struthers-Wells Co.	112
Sturtevant Co., B. F.	110
Terry Steam Turbine Co.	113
Thermoid Rubber Co.	11
Toledo Pipe Threading Machine Co.	88
Treadwell Co., M. H.	92
Trill Indicator Co.	72
Trimont Mfg. Co.	100
Turbo-Blower Co.	92
Turner-Fricke Mfg. Co.	112
Uehling Instrument Co.	106
Under-Feed Stoker Company of America	91
Underwood & Co., H. B.,	110
Union Steam Pump Co.	94
Universal Lubricator Co.	15
Vilter Mfg. Co.	113
Vogt Machine Co., Henry	104
Von Kokeritz & Co., R. G.	81
Vulcan Soot Cleaner Co.	103
Walton Co., F. S.	16 and 17
Washburn & Granger	92
Watson & McDaniel Co.	94
Watts-Campbell Co.	114
Westinghouse Elec. & Mfg. Co.	118
Wetherill & Co., Inc., Robt.	74
Wheeler Mfg. Co., C. H.	95
Whitlock Coil Pipe Co.	88
Wickes Boiler Co.	103
Willcox Engineering Co.	102
Williams & Co., J. H.	74
Williams Fdry. & Mach. Co.	98
Wing Mfg. Co., L. J.	91
Wise & Bailey	81
Worthington, Henry R.	95
Wright Mfg. Co.	78
Wyckoff & Son Co., A.	88
Yale & Towne Mfg. Co.	91
Yarnall-Waring Co.	85
Ziermore Regulator Co.	109

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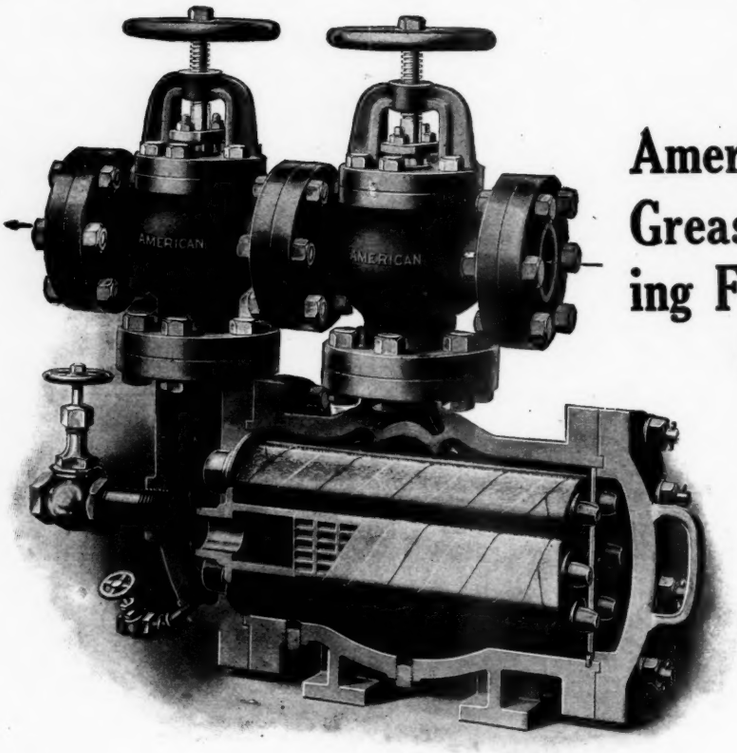

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Distinctive Features

Filtering surface equal to 320 times the area of the feed water pipes.

Renewals very easy to make. Every part easy of access. First cost low—maintenance cost low.

Has a device for applying a reverse current of steam for temporary cleaning.

This device should be in every plant where condensation is used for boiler feed.

It removes all oil and grease; prevents bagging of plates and consequent trouble, expense and danger.

It increases the boiler steaming capacity and reduces the coal bills.

The most thorough device of the kind, strong, substantial, everlasting. Write for full details of this and our other steam specialties.

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Pittsburg, 8076 Jenkins Arcade Bldg.
Atlanta, 525 Candler Bldg.
San Francisco, Monadnock Bldg.
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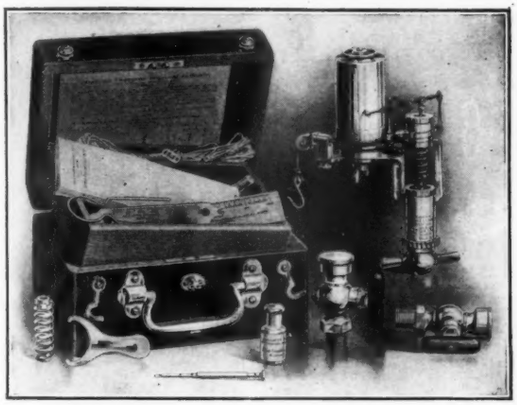
It depends entirely upon yourself. You won't get a better salary unless you are worth it, unless you can improve your work, can show savings to your employer. The engineer who makes no effort to do better work will have to watch other engineers pass him by in the race for better position, better pay. Nowadays every man must look out for himself, must work for his own advancement. And the engineer with an



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has a distinct advantage over the engineer who cannot indicate his engine. He knows and can prove that there is no steam waste in the cylinder, no leaky piston, no poorly adjusted valves.

He can show his employer that he is the right man for the job, that he is running things economically.

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Improved detent motion is patented and can only be used on the American-Thompson.

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Take your first step toward promotion and bigger pay today. Send us your first payment, $5.00, with references and we'll start your outfit on its way to you at once. We give you the privilege of examining your instrument for a period of five days. But don't put this important matter off any longer—NOW is the time to start helping yourself.

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American Steam Gauge & Valve Mfg. Company

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CLASSIFIED INDEX *to* ARTICLES ADVERTISED

Air Compressors
Allis-Chalmers Co..... 84
Ingersoll-Rand Co..... 98
Laidlaw-Dunn-Gordon Co....109
Perkins Co., Jno. B..... 88
Union Steam Pump Co..... 94

Alarms, Low Water
Detroit Lubricator Co..... 83
Elliott Co. 7
Lunkenheimer Co..... 4
Reliance Gauge Column Co... 79
Wright Mfg. Co..... 78

Alternators
Allis-Chalmers Co..... 84
General Electric Co.....101
Westinghouse Elec. & Mfg. Co.118

Belt Dressing
Cling-Surface Co. 99
Garlock Packing Co..... 9
Keystone Lubricating Co.... 3
Schieren Co., Chas. A..... 98
Smooth-On Mfg. Co..... 6
Walton Co., F. S.....16 and 17

Belt Lacing
Bristol Co.....4th cover
Flexible Steel Lacing Co..... 84
Schieren Co., Chas. A..... 98

Belting
Diamond Rubber Co..... 81
Garlock Packing Co..... 9
Jeffrey Mfg. Co..... 95
Morse Chain Co. 118
New York Belting & Pack. Co. 10
Peerless Rubber Mfg. Co..... 8
Quaker City Rubber Works... 80
Schieren Co., Chas. A..... 98

Belting, Chain and Drive
Morse Chain Co. 118

Blocks, Chain
Yale & Towne Mfg. Co..... 91

Blowers, Fan
Buffalo Forge Co..... 85
Ohio Blower Co..... 93
Sturtevant Co., B. F.....110
Terry Steam Turbine Co.....113
Turbo-Blower Co..... 92
Wing Mfg. Co., L. J..... 91

Blowers, Steam Jet
McClave-Brooks Co..... 14
Parson Mfg. Co..... 91
Schutte & Koerting Co...95, 102

Boiler Compound
Corliss Chemical Co. 106
Dearborn Drug and Chemical Works 5
Elliott Co. 7
Johns-Manville Co., H. W.... 73
Keystone Lubricating Co.... 3

Boiler Fronts
Casey-Hedges Co.....104

Boiler Setting
Air-Flex Co. 106
Betson Plastic Fire Brick Co..106
Harbison-Walker Refractories Co. 107
McLeod & Henry Co.....106

Boiler Tube Cap Reseating Machine
Elliott Co. 7
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7
National Tube Co..... 89

Boiler Tubes
National Tube Co..... 89

Boilers
Ames Iron Works.....114
Babcock & Wilcox Co.....104
Beggs & Co., James..... 97
Casey-Hedges Co.....104
Griffith & Wedge Co.....114
Griscom-Spencer Co.....1st cover
Harrisburg Foundry & Mach. Works 114
Harrison Safety Boiler Wks.. 63
Heine Safety Boiler Co.....105
Hewes & Phillips Iron Wks...116
Holyoke Steam Boiler Wks... 72
Keeler Co., E.....105
Kingsford Fdry. & Mach. Co..105
Minneapolis Steel & Mchy. Co.110
Morrin Climax Boiler Co.....104
New Bedford Valve Mfg. Co.. 85
Oil City Boiler Works.....105
Oil Well Supply Co.....104
Perkins Co., Jno. B..... 88
Robb Engineering Co., Ltd...104
Struthers-Wells Co.....112
Vilter Mfg. Co..... 113

Boilers—*Continued.*
Vogt Machine Co., Henry....104
Wickes Boiler Co.....103

Books
American School of Corr..... 73
International Corr. Schools... 67
McGraw-Hill Book Co.....108

Brick, Fire
Air-Flex Co. 106
Betson Plastic Fire Brick Co..106
Harbison-Walker Refractories Co. 107
McLeod & Henry Co.....106

Castings, Brass and Iron
Bruce-Macbeth Eng. Co..... 72
Builders Iron Foundry.....102
Hooven, Owens, Rentschler Co.113
Lunkenheimer Co., The..... 4
McClave-Brooks Co..... 14
Neemes Bros..... 92
Salamander Grate Bar Co.... 92
Treadwell & Co., M. H..... 92

Castings, Steel
Hooven, Owens, Rentschler Co.113

Cement, Heat Resisting
Air-Flex Co. 106

Cement, Iron
Johns-Manville Co., H. W.... 73
Smooth-On Mfg. Co..... 6

Cement, Rubber
Peerless Rubber Mfg. Co..... 8

Chemists
Smith, Rudy & Co.....103

Chimneys, Brick
Kellogg Co., M. W..... 78

Chimneys, Steel
Keeler Co., E.....105
Morrin Climax Boiler Co.....104

Clocks
American Steam Gauge and Valve Mfg. Co.....60 and 61

Clutches, Friction
Allis-Chalmers Co..... 84
Williams Fdry. & Mach. Co.. 98

Coal
Consolidation Coal Co..... 70
Pennsylvania Coal & Coke Co. 90

Coal and Ash Handling Machinery
Green Engineering Co..... 92

Cocks, Blow-off
Elliott Co. 7

Cocks, Gage
American Steam Gauge and Valve Mfg. Co.....60 and 61
Chaplin-Fulton Mfg. Co.....106
Huyette Co., Paul B..... 88
Jenkins Bros..... 65
Lunkenheimer Co., The..... 4
Ohio Blower Co..... 93
Reliance Gauge Column Co... 79
"S-C" Regulator Co....4th cover
Star Brass Mfg. Co.....111
Wright Mfg. Co..... 78

Cocks, Steam
Dart Mfg. Co., E. M..... 88
Lunkenheimer Co..... 4
National Tube Co..... 89
Schutte & Koerting Co...95, 102

Combustion Chamber, Back Arch
Air-Flex Co. 106
Betson Plastic Fire Brick Co.106
Harbison-Walker Refractories Co. 107
McLeod & Henry Co.....106

Combustion Recorders
Precision Instrument Co.....103
Uehling Instrument Co.....106

Compound, Commutator
Dixon Crucible Co., Jos..... 83

Condensers
Alberger Condenser Co..... 95
Allis-Chalmers Co..... 84
Anderson Co., V. D..... 78
Baragwanath & Son, Wm.... 96
Cameron Steam Pump Works, A. S..... 94
Epping-Carpenter Co..... 95
Griscom-Spencer Co.....1st cover

Condensers—*Continued.*
Kellogg Co., M. W..... 78
Minneapolis Steel & Mchy. Co.110
Schutte & Koerting Co...95, 102
Union Steam Pump Co..... 94
Wheeler Mfg. Co., C. H..... 95

Controllers, Electric
General Electric Co.....101
Westinghouse Elec. & Mfg. Co.118

Controllers, Feed Water
Chaplin-Fulton Mfg. Co.....106
Elliott Co. 7
Mason Regulator Co..... 86
Northern Equipment Co..... 72
Squires Co., C. E..... 79
Ziermore Regulator Co.....109

Conveying Machinery
Jeffrey Mfg. Co..... 95

Cooling Plants
Schutte & Koerting Co...95, 102

Cooling Towers
Wheeler Mfg. Co., C. H..... 95

Cordage
American Mfg. Co..... 98
Columbian Rope Co..... 98

Correspondence Schools
American School of Corres... 73
International Corr. Schools... 67

Couplings, Flexible Shaft
Bruce-Macbeth Engine Co..... 82
Hooven, Owens, Rentschler Co.113

Couplings, Hose
Ingersoll-Rand Co..... 98

Couplings, Pipe
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Coverings, Pipe and Boiler
Johns-Manville Co., H. W.... 73
Wyckoff & Son Co., A..... 88

Cranes
Yale & Towne Mfg. Co..... 91

Crank Pin Oiler
Richardson-Phenix Co. 83

Curbs, Manhole
Armstrong Mfg. Co..... 88

Cylinder Boring Bars
Underwood & Co., H. B.....110

Die Stocks
Armstrong Mfg. Co..... 88
Bignall & Keeler Mfg. Co.... 88
Curtis & Curtis Co..... 85
Toledo Pipe Threading Mach. Co. 88

Draft, Mechanical
Buffalo Forge Co..... 85
Parson Mfg. Co..... 91
Schutte & Koerting Co...95, 102
Sturtevant Co., B. F.....110
Turbo-Blower Co..... 92
Wing Mfg. Co., L. J..... 91

Drills, Upright
Barnes Co., W. F. & John.... 83

Dust Collectors
Ohio Blower Co..... 93
Sturtevant Co., B. F.....110

Dynamos
Allis-Chalmers Co..... 84
American Engine Co.....113
Bruce-Macbeth Eng. Co..... 82
General Electric Co.....101
Ridgway Dynamo and Engine Co. 113
Sturtevant Co., B. F.....110
Terry Steam Turbine Co.....113
Westinghouse Elec. & Mfg. Co.118

Economizers, Fuel
Parsons Mfg. Co..... 91
Sturtevant Co., B. F.....110

Ejectors
Beggs & Co., James..... 97
Lunkenheimer Co..... 4
Penberthy Injector Co..... 13
Schutte & Koerting Co...95, 102

Electric Current
New York Edison Co.....112

Engine Oil
Remington Oil Engine Co....109

Engine Repairs
Rooksby & Co., E. J.....109
Underwood & Co., H. B.....110

Engine Stops
Schutte & Koerting Co...95, 102

Engines, Combustion
Alberger Gas Eng. Co.....112
Allis-Chalmers Co..... 84
Bogart Gas Power Engineering Co. 110
Bruce-Macbeth Eng. Co..... 85
Buckeye Engine Co.....114
Du Bois Iron Works.....110
Foos Gas Engine Co.....116
Minneapolis Steel & Mchy. Co.110
Struthers-Wells Co.....112
Turner-Fricke Mfg. Co.....112

Engines, Pumping
Hooven, Owens, Rentschler Co.113

Engines, Steam
Allis-Chalmers Co..... 84
American Eng. Co.....113
Ames Iron Works.....114
Ball & Wood Co.....116
Ball Engine Co.....115
Beggs & Co., James..... 97
Buckeye Engine Co.....114
Buffalo Forge Co..... 85
Cooper Co., C. & G.....116
Du Bois Iron Works.....110
Fitchburg Steam Engine Co.. 116
Griffith & Wedge Co.....114
Griscom-Spencer Co.....1st cover
Harris Steam Eng. Co., Wm. A.113
Harrisburg Fdry & Mach. Wks.114
Hewes & Phillips Iron Wks..116
Hooven, Owens, Rentschler Co.113
McIntosh, Seymour & Co....116
Minneapolis Steel & Mchy. Co.110
Perkins Co., Jno. B..... 88
Providence Engineering Wks.116
Ridgway Dynamo & Engine Co.113
Rollins Engine Co.....117
Skinner Engine Co.....114
Sturtevant Co., B. F.....110
Vilter Mfg. Co.....113
Watts-Campbell Co.....114

Exhaust Heads
Burt Mfg. Co..... 18
Elliott Co. 7
Hoppes Mfg. Co..... 96
Ohio Blower Co..... 93
Patterson & Co., Frank L.... 74
Robertson & Sons, Jas. L.... 69
Sturtevant Co., B. F.....110
Whitlock Coil Pipe Co..... 88
Wright Mfg. Co..... 78

Expansion Joints
Alberger Condenser Co..... 95
National Tube Co..... 89

Fans, Electric
General Electric Co.....101
Westinghouse Elec. & Mfg. Co.118

Fans, Exhaust and Ventilating
Anderson Co., V. D..... 78
Buffalo Forge Co..... 85
General Electric Co.....101
Power Specialty Co..... 81
Schutte & Koerting Co...95, 102
Sturtevant Co., B. F.....110
Turbo-Blower Co..... 92
Westinghouse Elec. & Mfg. Co.118
Wing Mfg. Co., L. J..... 91

Feed Water Weighers
Wilcox Engineering Co.....102

Feeders, Boiler Compound
Richardson-Phenix Co. 83

Feeders, Furnace
Ohio Blower Co..... 93

Filters, Oil
Burt Mfg. Co..... 18
Elliott Co. 7
Liberty Mfg. Co..... 7
Richardson-Phenix Co..... 83
Robertson & Sons, Jas. L.... 69
Wright Mfg. Co..... 78

Filters, Water
Griscom-Spencer Co.....1st cover
Scaife & Sons Co., Wm. B....104

Fire Clay
Air-Flex Co. 106
Harbison-Walker Refractories Co. 107
McLeod & Henry Co.....106

Firebox Blocks
Air-Flex Co. 106
Betson Plastic Fire Brick Co.106
Harbison-Walker Refractories Co. 107
McLeod & Henry Co.....106

All Kinds of Steam Engines Need Cochrane Separators

to protect them against damage from water brought over from the boiler or condensed in the steam line, and **to remove from the steam the constant small percentage of water** which is always present unless the steam is superheated, and sometimes even then, since it is a well-known fact that water will flow along the bottom of a pipe containing superheated steam.

By keeping this water out of the engine, the separator much more than pays for itself day by day, in addition to the protection against damage. Where engines are fed only with dry steam, less cylinder oil is required. In some cases, we have known the amount of oil to be reduced by 33 to 50%, after the installation of Cochrane Separators. The blades of turbines fed with dry steam last much longer than the blades of turbines fed with wet steam.

The steam efficiency of turbines is further greatly increased by supplying only dry steam, since each pound of water in the steam entails the consumption of an extra pound of steam to make up for the friction which the water creates. This has been shown by repeated tests.

Cochrane Receiver Oil Separators should always be installed where the exhaust from reciprocating engines is to be used in low pressure turbines. The receiver capacity equalizes the fluctuations in pressure, and the separator removes from the steam all oil and water, so that the turbine operates at its highest efficiency, unaffected by erosion of the blades or accumulations of grease, and the condensate from the surface condenser is entirely suitable for boiler feeding, and can be used in place of impure raw water.

We also build separators for removing water from compressed air and other gases. Write for a copy of our "*Separator Talks*," and if you have some especially difficult separation problem, submit it to our engineers for solution.

Harrison Safety Boiler Works

17th and Clearfield Sts., Philadelphia, Pa.

Fittings, Ammonia
American Steam Gauge and Valve Mfg. Co.....60 and 61

Fittings, Steel
Nelson Valve Co..... 87

Flanges
Ball & Wood Co.....116
Dart Mfg. Co., E. M..... 88
Jefferson Union Co..... 10
National Tube Co..... 89

Floats
Anderson Co., V. D..... 78
Schutte & Koerting Co...95, 102

Flue Gas Analysis Instruments
Pierce Co., Wm. B.....2d cover

Forgings, Drop
Williams & Co., J. H..... 74

Furnace Door Arch
Air-Flex Co. 106
Harbison-Walker Refractories Co. 107
Holyoke Steam Boiler Works. 72
McLeod & Henry Co.....106

Furnace Linings
Harbison-Walker Refractories Co. 107
Holyoke Steam Boiler Works.. 72

Furnaces, Smokeless
Green Engineering Co..... 92
Holyoke Steam Boiler Works. 72
McClave-Brooks Co..... 14
Mellor Furnace Engr. Co..... 72
Murphy Iron Works..... 90

Gage Boards
American Steam Gauge and Valve Mfg. Co.....60 and 61
Star Brass Mfg. Co.....111

Gage Glasses
American Steam Gauge and Valve Mfg. Co.....60 and 61
Chesterton Co., A. W..... 84
Garlock Packing Co..... 9
Peerless Rubber Mfg. Co..... 8
Quaker City Rubber Works... 80
Rogers Co., H. A..... 94
Von Kokeritz & Co., R. G.... 81

Gage Testing Outfit
American Steam Gauge and Valve Mfg. Co.....60 and 61
Star Brass Mfg. Co.....111

Gages, Draft
American Steam Gauge and Valve Mfg. Co.....60 and 61
Bristol Co.....4th cover
Star Brass Mfg. Co.....111

Gages, Pressure
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashton Valve Co..... 86
Crosby Steam Gage & Valve Co. 89
Star Brass Mfg. Co.....111

Gages, Recording
American Steam Gauge and Valve Mfg. Co.....60 and 61
Ashton Valve Co..... 86
Bristol Co.....4th cover
Star Brass Mfg. Co.....111
Uehling Instrument Co..... 10

Gages, Vacuum
American Steam Gauge and Valve Mfg. Co.....60 and 61
Schutte & Koerting Co...95, 102
Star Brass Mfg. Co.....111

Gages, Water
American Steam Gauge and Valve Mfg. Co.....60 and 61
Greene, Tweed & Co., 82 and 4th cover
Huyette Co., Paul B..... 88
Jenkins Bros..... 65
Lunkenheimer Co..... 4
Ohio Blower Co..... 93
Reliance Gauge Column Co... 79
Star Brass Mfg. Co.....111
Wright Mfg. Co..... 78

Gas Exhausters
Ohio Blower Co..... 93

Gas Producers
Bogart Gas Power Engineering Co. 110
Du Bois Iron Works.....110
Foos Gas Engine Co.....116
Griscom-Spencer Co.....1st cover
Minneapolis Steel & Mchy. Co.110

Gaskets
Cancos Mfg. Co..... 81
Diamond Rubber Co..... 81
Eureka Packing Co..... 68
Garlock Packing Co..... 9
Greene, Tweed & Co., 82 and 4th cover
Jenkins Bros..... 65
Johns-Manville Co., H. W.... 73
Keeler Co., E.....105

Gaskets—*Continued.*
New York Belting & Packing Co. 12
Peerless Rubber Mfg. Co..... 8
Quaker City Rubber Works... 80

Gears
New Process Raw Hide Co... 98

Generating Sets
American Engine Co.....113
Foos Gas Engine Co.....116
General Electric Co.....101
Harris Steam Engine Co., Wm.113
Harrisburg Foundry and Machine Works.....114
Ridgway Dynamo & Engine Co.113
Sturtevant Co., B. F.....110
Westinghouse Elec. & Mfg. Co.118

Governors, Pump
Chaplin-Fulton Mfg. Co.....106
Elliott Co. 7
Mason Regulator Co..... 86
Northern Equipment Co..... 72
"S-C" Regulator Co....4th cover
Squires Co., C. E..... 79
Watson & McDaniel Co..... 94
Ziermore Regulator Co.....109

Governors, Pump Speed
Mason Regulator Co..... 86
Ziermore Regulator Co.....109

Graphite
Dixon Crucible Co., Jos..... 83
Garlock Packing Co..... 9

Grates
Casey-Hedges Co.....104
Green Engineering Co..... 92
Long Grate Bar Co..... 90
McClave-Brooks Co..... 14
Mellor Furnace Engr. Co..... 72
Neemes Bros..... 92
Perfection Grate Co..... 92
Salamander Grate Bar Co.... 92
Standard Grate Co..... 92
Treadwell & Co., M. H..... 92
Washburn & Granger Co..... 92

Grease
Albany Lubricating Co..... 76
Appleby Co., George..... 83
Dearborn Drug & Chemical Works 5
Dixon Crucible Co., Jos..... 83
Kellogg & Co., E. H..... 78
Keystone Lubricating Co..... 3
Walton Co., F. S.....16 and 17

Grease Extractors
Beggs & Co., James..... 97
Elliott Co. 7
Griscom-Spencer Co.....1st cover

Heaters and Purifiers, Feed Water
Alberger Condenser Co..... 95
Baragwanath & Son, Wm..... 96
Blake & Knowles Steam Pump Works 96
Casey-Hedges Co.....104
Elliott Co. 7
Griscom-Spencer Co.....1st cover
Harrison Safety Boiler Wks.. 63
Hoppes Mfg. Co..... 96
Minneapolis Steel & Mchy. Co.110
National Pipe Bending Co.... 96
Open Coil Heater & Purifier Co. 96
Patterson & Co., Frank L.... 74
Robertson & Sons, Jas. L.... 69
Wheeler Mfg. Co., C. H..... 95
Whitlock Coil Pipe Co..... 88
Wickes Boiler Co.....103
Willcox Engr. Co.....102

Heating and Ventilating Systems
Ohio Blower Co..... 93
Schutte & Koerting Co...95, 102
Wing Mfg. Co., L. J..... 91

Heating, Central Station
American District Steam Co..109

Hoists, Combustion Engine
Foos Gas Engine Co.....116

Hoists, Electric
Allis-Chalmers Co..... 84
Yale & Towne Mfg. Co..... 91

Hoists, Hand
Yale & Towne Mfg. Co..... 91

Hose, Metal
American Metal Hose Co..... 98
Liberty Mfg. Co..... 7
Pennsylvania Flexible Metallic Tubing Co..... 75
Quaker City Rubber Works... 80

Hose, Rubber
Diamond Rubber Co..... 81
Garlock Packing Co..... 9
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7
New York Belting & Packing Co. 12
Peerless Rubber Mfg. Co..... 8
Pennsylvania Flexible Metallic Tubing Co..... 75
Quaker City Rubber Works... 80

Ice and Refrigerating Machinery
Vogt Machine Co., Henry....104
Watts-Campbell Co. 114

Ice Machine Repairs
Underwood & Co., H. B.....110

Indicators, Ammonia
American Steam Gauge and Valve Mfg. Co.....60 and 61
Star Brass Mfg. Co.....111

Indicators, Combustion Engine
American Steam Gauge and Valve Mfg. Co.....60 and 61
Star Brass Mfg. Co.....111
Trill Indicator Co..... 72

Indicators, Speed
Star Brass Mfg. Co..... 111
Starrett Co., L. S..... 90

Indicators, Steam Engine
American Steam Gauge and Valve Mfg. Co.....60 and 61
Crosby Steam Gage & Valve Co. 89
Robertson & Sons, Jas. L.... 69
Star Brass Mfg. Co.....111
Trill Indicator Co..... 72

Injectors
Jenkins Bros..... 65
Lunkenheimer Co..... 4
Penberthy Injector Co..... 13
Robertson & Sons, Jas. L.... 69
Schutte & Koerting Co...95, 102

Lamps, Electric
General Electric Co.....101
Johns-Manville Co., H. W.... 73
Westinghouse Elec. & Mfg. Co.118

Lathes, Foot Power
Barnes Co., W. F. & John.... 83

Lubricators, Cylinder
Detroit Lubricator Co..... 83
Greene, Tweed & Co., 82 and 4th cover
Griscom-Spencer Co.....1st cover
Lunkenheimer Co..... 4
Manzel Bros. Co..... 83
Robertson & Sons, Jas. L.... 69
Richardson-Phenix Co..... 83
Star Brass Mfg. Co.....111
Universal Lubricator Co..... 15

Lubricators, Force Feed
Greene, Tweed & Co., 82 and 4th cover
Lunkenheimer Co..... 4
Richardson-Phenix Co..... 83
Star Brass Mfg. Co.....111

Machinists, General
Bruce-Macbeth Eng. Co..... 72
Providence Eng. Wks.....116

Mats and Matting
Diamond Rubber Co..... 81
New York Belting & Packing Co 12
Peerless Rubber Mfg. Co.... 8

Metal, Bearing
Magnolia Metal Co.....110

Meters, Steam
General Electric Co.....101
St. John, G. C..... 84

Meters, Water
Builders Iron Foundry.....102
Elliott Co. 7

Micrometers
Starrett Co., L. S..... 90

Milling Machines, Portable
Underwood & Co., H. B.....110

Motors, Electric
Allis-Chalmers Co..... 84
American Engine Co.....113
General Electric Co.....101
Ridgway Dynamo & Engine Co 113
Sturtevant Co., B. F.....110
Westinghouse Elec. & Mfg. Co.118

Motors, Water
Elliott Co. 7
Lagonda Mfg. Co.....3d cover
Liberty Mfg. Co..... 7

Oil and Grease Cups
Albany Lubricating Co..... 76
Detroit Lubricating Co..... 83
Keystone Lubricating Co.... 3
Liberty Mfg. Co..... 7
Lunkenheimer Co..... 4
New York & New Jersey Lubricant Co. 83
Richardson-Phenix Co..... 83
Star Brass Mfg. Co.....111
Universal Lubricator Co..... 15

Oil Burners
Hammel Oil Burner Co..... 90
Lunkenheimer Co..... 4
Parson Mfg. Co..... 91

Oil Reservoirs
Burt Mfg. Co..... 18
Richardson-Phenix Co..... 83

Oil Tanks
Richardson-Phenix Co..... 83

Oiling Systems
Albany Lubricating Co..... 76
Burt Mfg. Co..... 18
Detroit Lubricator Co..... 83
Elliott Co. 7
Lunkenheimer Co..... 4
Richardson-Phenix Co..... 83

Oils
Albany Lubricating Co..... 76
Dearborn Drug & Chemical Works 5
New York & New Jersey Lubricant Co..... 83
Walton Co., F. S.....16 and 17

Packing, Flange
Cancos Mfg. Co..... 81
Chesterton Co., A. W..... 84
Diamond Rubber Co..... 81
Eureka Packing Co..... 68
Garlock Packing Co..... 9
Greene, Tweed & Co., 82 and 4th cover
Jenkins Bros..... 65
Johns-Manville Co., H. W.... 73
New York Belting & Packing Co. 12
Peerless Rubber Mfg. Co.... 8
Quaker City Rubber Works... 80
Smooth-On Mfg. Co..... 6
Thermoid Rubber Co..... 11
Von Kokeritz & Co., R. G.... 81
Wise & Bailey..... 81

Packing, Hydraulic
Johns-Manville Co., H. W.... 73
Quaker City Rubber Works... 80
Von Kokeritz & Co., R. G.... 81
Wise & Bailey..... 81

Packing, Pump Valve
Cancos Mfg. Co..... 81
Diamond Rubber Co..... 81
Quaker City Rubber Works... 80
Von Kokeritz & Co., R. G.... 81
Wise & Bailey..... 81

Packing, Rod
Cancos Mfg. Co..... 81
Chesterton Co., A. W..... 84
Diamond Rubber Co..... 81
Eureka Packing Co..... 68
Garlock Packing Co..... 9
Greene, Tweed & Co., 82 and 4th cover
Johns-Manville Co., H. W.... 73
New York Belting and Packing Co..... 12
Peerless Rubber Mfg. Co..... 8
Power Specialty Co..... 81
Quaker City Rubber Works... 80
Thermoid Rubber Co..... 11
Von Kokeritz & Co., R. G..... 81
Wise & Bailey..... 81

Pipe
Ball & Wood Co.....116
Kellogg & Co., M. W..... 78
National Tube Co..... 89

Pipe Bending
Ball & Wood Co.....116
Kellogg Co., M. W..... 78
National Pipe Bending Co.... 96
Whitlock Coil Pipe Co..... 88

Pipe Clamp
Yarnall & Waring Co..... 85

Pipe Coils
National Pipe Bending Co.... 96
National Tube Co..... 89
Whitlock Coil Pipe Co..... 88

Pipe Cutting and Threading Machines
Armstrong Mfg. Co..... 88
Bignall & Keeler Mfg. Co.... 88
Borden Co. 88
Curtis & Curtis Co..... 85
Toledo Pipe Threading Machine Co..... 88
Trimont Mfg. Co.....100

Piping, Blower
Ohio Blower Co..... 93

Piping, High Pressure
Kellogg Co., M. W..... 78

Planimeters
American Steam Gauge and Valve Mfg. Co.....60 and 61
Robertson & Sons, Jas. L.... 69

Polish, Metal
Hoffman, Geo. W..... 98
Johns-Manville Co., H. W.... 73

Publishers
American School of Corr..... 73
International Corr. Schools... 67
McGraw-Hill Book Co.....108

Pulleys
Minneapolis Steel & Mchy. Co.110

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Pumps, Air
Cameron Steam Pump Wks., A. S. ... 94
Du Bois Iron Works ... 110
Goulds Mfg. Co. ... 94
Wheeler Mfg. Co., C. H. ... 95

Pumps, Centrifugal
Alberger Condenser Co. ... 95
Allis-Chalmers Co. ... 84
Terry Steam Turbine Co. ... 113
Worthington, Henry R. ... 95

Pumps, Deep Well
Cameron Steam Pump Wks., A. S. ... 94
Deming Co. ... 95

Pumps, Electric
Deming Co. ... 95
Du Bois Iron Works ... 110
Goulds Mfg. Co. ... 94
Westinghouse Elec. & Mfg. Co. 118

Pumps, Oil
Burt Mfg. Co. ... 18
Cameron Steam Pump Wks., A. S. ... 94
Du Bois Iron Works ... 110
Goulds Mfg. Co. ... 94
Lunkenheimer Co. ... 4
Manzel Bros. Co. ... 83
Star Brass Mfg. Co. ... 111

Pumps, Oil Force-feed
Detroit Lubricator Co. ... 83
Lunkenheimer Co. ... 4
Richardson-Phenix Co. ... 83

Pumps, Pneumatic
Ingersoll-Rand Co. ... 98

Pumps, Power
Deming Co. ... 95
Du Bois Iron Works ... 110
Goulds Mfg. Co. ... 94
Quimby, Inc., Wm. E. ... 94
Patterson & Co., Frank L. ... 74
Perkins Co., Jno. B. ... 88
Union Steam Pump Co. ... 94
Whitlock Coil Pipe Co. ... 88

Pumps, Screw
Quimby, Inc., Wm. E. ... 94

Pumps, Steam
Allis-Chalmers Co. ... 84
Cameron Steam Pump Wks., A. S. ... 94
Du Bois Iron Works ... 110
Epping-Carpenter Co. ... 95
Goulds Mfg. Co. ... 94
Ingersoll-Rand Co. ... 98
Jamieson & Co., M. W. ... 95
Minneapolis Steel & Mchy. Co. 110
Perkins Co., Jno. B. ... 88
Union Steam Pump Co. ... 94
Wheeler Mfg. Co., C. H. ... 95
Worthington, Henry R. ... 95

Pumps, Vacuum
Alberger Condenser Co. ... 95
Cameron Steam Pump Wks., A. S. ... 94
Goulds Mfg. Co. ... 94
Union Steam Pump Co. ... 94
Wheeler Mfg. Co., C. H. ... 95

Pyrometers
American Steam Gauge and Valve Mfg. Co. ... 60 and 61

Rams, Steam
Penberthy Injector Co. ... 13

Reducing Wheels
American Steam Gauge and Valve Mfg. Co. ... 60 and 61
Robertson & Sons, Jas. L. ... 69
Trill Indicator Co. ... 72

Regulators, Damper
Elliott Co. ... 7
Lagonda Mfg. Co. ... 3d cover
Mason Regulator Co. ... 86
Robertson & Sons, Jas. L. ... 69
"S-C" Regulator Co. ... 4th cover
Turbo-Blower Co. ... 92

Regulators, Feed Water
Cade & Knapp ... 73
Elliott Co. ... 7
Lagonda Mfg. Co. ... 3d cover
Liberty Mfg. Co. ... 7
Northern Equipment Co. ... 72
"S-C" Regulator Co. ... 4th cover
Squires Co., C. E. ... 79
Ziermore Regulator Co. ... 109

Regulators, Pressure
American District Steam Co. 109
Chaplin-Fulton Mfg. Co. ... 106
Elliott Co. ... 7
Hughson Steam Specialty Co. 89
Lagonda Mfg. Co. ... 3d cover
Mason Regulator Co. ... 86
Northern Equipment Co. ... 72
Squires Co., C. E. ... 79
Ziermore Regulator Co. ... 109

Regulators, Pump
Elliott Co. ... 7
Hughson Steam Specialty Co. 89
Mason Regulator Co. ... 86
"S-C" Regulator Co. ... 4th cover
Squires Co., C. E. ... 79
Ziermore Regulator Co. ... 109

Revolution Counters
American Steam Gauge and Valve Mfg. Co. ... 60 and 61

Rheostats
General Electric Co. ... 101

Rope, Transmission
American Mfg. Co. ... 98
Columbian Rope Co. ... 98

Rubber Joints
Diamond Rubber Co. ... 81
Quaker City Rubber Works ... 80

Rules
Johnson Rule Mfg. Co. ... 94

Second Hand Machinery
Conard, Thos. P. ... 74
Machinery Brokerage Co. ... 74
Wetherill & Co., Robt. ... 74

Separators, Ammonia
Elliott Co. ... 7
Harrison Safety Boiler Wks. ... 63

Separators, Oil
Austin Separator Co. ... 78
Baragwanath & Son, Wm. ... 96
Elliott Co. ... 7
Harrison Safety Boiler Wks. ... 63
Hoppes Mfg. Co. ... 96
Liberty Mfg. Co. ... 7
Nashua Machine Co. ... 78
Ohio Blower Co. ... 93
Robertson & Sons, Jas. L. ... 69
Wright Mfg. Co. ... 78

Separators, Steam
Austin Separator Co. ... 78
Baragwanath & Son, Wm. ... 96
Elliott Co. ... 7
Griscom-Spencer Co. ... 1st cover
Harrison Safety Boiler Wks. ... 63
Hoppes Mfg. Co. ... 96
Liberty Mfg. Co. ... 7
Nashua Machine Co. ... 78
Ohio Blower Co. ... 93
Patterson & Co., Frank L. ... 74
Robertson & Sons, Jas. L. ... 69
Whitlock Coil Pipe Co. ... 88
Wright Mfg. Co. ... 78

Shafting, Alining and Leveling Apparatus
Kinkead Mfg. Co. ... 96

Sight Feeds
Richardson-Phenix Co. ... 83

Skylights
Burt Mfg. Co. ... 18

Spray Nozzles
Buffalo Forge Co. ... 85

Stokers, Chain Grate
Green Engineering Co. ... 92

Stokers, Mechanical
American Ship Windlass Co. ... 91
Babcock & Wilcox Co. ... 104
Green Engineering Co. ... 92
Lagonda Mfg. Co. ... 3d cover
McClave-Brooks Co. ... 14
Murphy Iron Works ... 90
Parson Mfg. Co. ... 91
Under-Feed Stoker Company of America ... 91

Strainers, Pump Suction
American Ship Windlass Co. ... 91
Elliott Co. ... 7

Strainers, Water
Liberty Mfg. Co. ... 7

Superheaters
Babcock & Wilcox Co. ... 104
Nelson Valve Co. ... 87
Power Specialty Co. ... 81
Providence Engineering Wks. 116

Switchboards
General Electric Co. ... 101
Westinghouse Elec. & Mfg. Co. 118

Switches, Electric
General Electric Co. ... 101

Tachometers
Schuchardt & Schutte ... 84

Tanks
Griscom-Spencer Co. ... 1st cover

Taps, Stocks and Dies
Armstrong Mfg. Co. ... 88
Bignall & Keeler Mfg. Co. ... 88
Curtis & Curtis Co. ... 85
Toledo Pipe Threading Machine Co. ... 88

Thermometers
Bristol Co. ... 4th cover

Tools, Portable Repair
Underwood & Co., H. B. ... 91

Transformers and Converters
General Electric Co. ... 101
Jeffrey Mfg. Co. ... 95
Westinghouse Elec. & Mfg. Co. 118

Traps, Steam
American District Steam Co. 109
Anderson Co., V. D. ... 78
Chaplin-Fulton Mfg. Co. ... 106

Traps, Steam—*Continued.*
Elliott Co. ... 7
Griscom-Spencer Co. ... 1st cover
Jenkins Bros. ... 65
Lytton Mfg. Corporation ... 71
Morehead Mfg. Co. ... 82
Nashua Machine Co. ... 78
Newhall Eng. Co., Geo. M. ... 77
Ohio Blower Co. ... 93
Open Coil Heater & Purifier Co ... 96
Reliance Gauge Column Co. ... 79
Schutte & Koerting Co. ... 95 and 102
Squires Co., C. E. ... 79
Watson & McDaniel Co. ... 94
Wright Mfg. Co. ... 78

Traps, Vacuum
Griscom-Spencer Co. ... 1st cover
Lytton Mfg. Corporation ... 71
Nashua Machine Co. ... 78
Open Coil Heater & Purifier Co. ... 96

Tube Cap Reseating Machines
Lagonda Mfg. Co. ... 3d cover
Liberty Mfg. Co. ... 7

Tube Cleaners
Bayer Steam Soot Blower Co. 105
Chesterton Co., A. W. ... 84
Garlock Packing Co. ... 9
Johns-Manville Co., H. W. ... 73
Lagonda Mfg. Co. ... 3d cover
Liberty Mfg. Co. ... 7
Pierce Co., Wm. B. ... 2d cover
Robertson & Sons, Jas. L. ... 69
Simonds & Co., G. L. ... 103
St. John, G. C. ... 84
Vulcan Soot Cleaner Co. ... 103

Tube Cutters
Lagonda Mfg. Co. ... 3d cover
Liberty Mfg. Co. ... 7

Tubing
Johns-Manville Co., H. W. ... 73
National Tube Co. ... 89

Turbines, Hydraulic
Allis-Chalmers Co. ... 84

Turbines, Steam
Allis-Chalmers Co. ... 84
General Electric Co. ... 101
Hooven, Owens, Rentschler Co. 113
Sturtevant Co., B. F. ... 110
Terry Steam Turbine Co. ... 113

Unions
Dart Mfg. Co., E. M. ... 88
Jefferson Union Co. ... 10
Lunkenheimer Co. ... 4
National Tube Co. ... 89

Valve Balls
Diamond Rubber Co. ... 81

Valve Disks
Diamond Rubber Co. ... 81

Valve Washers, Leather
Schieren Co., Chas. A. ... 98

Valves, Ammonia
Chapman Valve Mfg. Co. ... 89
Monarch Valve & Mfg. Co. ... 89

Valves, Angle
Homestead Valve Mfg. Co. ... 89
Lunkenheimer Co. ... 4
Monarch Valve & Mfg. Co. ... 89
National Tube Co. ... 89
Nelson Valve Co. ... 87
New Bedford Valve Mfg. Co. ... 85
Star Brass Mfg. Co. ... 111

Valves, Back Pressure
Hughson Steam Specialty Co. 89
Jenkins Bros. ... 65
Perkins Co., Jno. B. ... 88

Valves, Blow-off
Elliott Co. ... 7
Homestead Valve Mfg. Co. ... 89
Jenkins Bros. ... 65
Liberty Mfg. Co. ... 7
Lunkenheimer Co. ... 4
Yarnall-Waring Co. ... 85
Ziermore Regulator Co. ... 109

Valves, By Pass
Mason Regulator Co. ... 84
Nelson Valve Co. ... 87

Valves, Check
Greene, Tweed & Co., 82 and 4th cover
Jenkins Bros. ... 65
Lunkenheimer Co. ... 4
National Tube Co. ... 89
Nelson Valve Co. ... 87

Valves, Cylinder Relief
American Steam Gauge and Valve Mfg. Co. ... 60 and 61
Lunkenheimer Co. ... 4
Perkins Co., Jno. B. ... 88
Star Brass Mfg. Co. ... 111

Valves, Exhaust Relief
Alberger Condenser Co. ... 95
Jenkins Bros. ... 65

Valves, Float
Schade Valve Mfg. Co. ... 85
Golden-Anderson Valve Specialty Co. ... 85

Valves, Free Exhaust
Schutte & Koerting Co. ... 95 and 102

Valves, Gate
Chapman Valve Mfg. Co. ... 89
Detroit Lubricator Co. ... 83
Greene, Tweed & Co., 82 and 4th cover
Jenkins Bros. ... 65
Lunkenheimer Co. ... 4
Monarch Valve & Mfg. Co. ... 89
National Tube Co. ... 89
Nelson Valve Co. ... 87
Pittsburgh Valve, Fdry. & Construction Co. ... 89

Valves, Globe
Detroit Lubricator Co. ... 83
Golden-Anderson Valve Specialty Co. ... 85
Jenkins Bros. ... 65
Lunkenheimer Co. ... 4
National Tube Co. ... 89
Nelson Valve Co. ... 87
New Bedford Valve Mfg. Co. ... 85
Pittsburgh Valve, Fdry. and Construction Co. ... 89
Star Brass Mfg. Co. ... 111

Valves, Piston
Baker Valve Co. ... 110

Valves, Pump
Garlock Packing Co. ... 9
Jenkins Bros. ... 65
New York Belting & Packing Co. ... 12
Peerless Rubber Mfg. Co. ... 8
Quaker City Rubber Works ... 80
Schade Valve Mfg. Co. ... 85

Valves, Reducing
Mason Regulator Co. ... 86

Valves, Regrinding
Lunkenheimer Co. ... 4
National Tube Co. ... 89
Nelson Valve Co. ... 87

Valves, Regulating
Hughson Steam Specialty Co. 89
Lunkenheimer Co. ... 4
Mason Regulator Co. ... 86
Nelson Valve Co. ... 87
Schade Valve Mfg. Co. ... 85
Ziermore Regulator Co. ... 109

Valves, Return Stop
Lagonda Mfg. Co. ... 3d cover

Valves, Safety
American Steam Gauge and Valve Mfg. Co. ... 60 and 61
Ashton Valve Co. ... 86
Crosby Steam Gage & Valve Co. ... 89
Detroit Lubricator Co. ... 83
Jenkins Bros. ... 65
Lunkenheimer Co. ... 4
National Tube Co. ... 89
Pittsburgh Valve, Fdry. and Construction Co. ... 89
Star Brass Mfg. Co. ... 111

Valves, Stop Check
Jenkins Bros. ... 65
Lagonda Mfg. Co. ... 3d cover
Perkins Co., Jno. B. ... 88
Schutte & Koerting Co. ... 95 and 102

Valves, Superheated Steam
Chapman Valve Mfg. Co. ... 89
Lunkenheimer Co. ... 4
Nelson Valve Co. ... 87

Valves, Tank
Nelson Valve Co. ... 87

Valves, Throttle
Detroit Lubricator Co. ... 83

Valves, Trip Throttle
Schutte & Koerting Co. ... 95 and 102

Ventilators
Burt Mfg. Co. ... 18
Ohio Blower Co. ... 93
Schutte & Koerting Co. ... 95 and 102
Turbo-Blower Co. ... 92
Wing Mfg. Co., L. J. ... 91

Vises
Armstrong Mfg. Co. ... 88
Williams & Co., J. H. ... 74

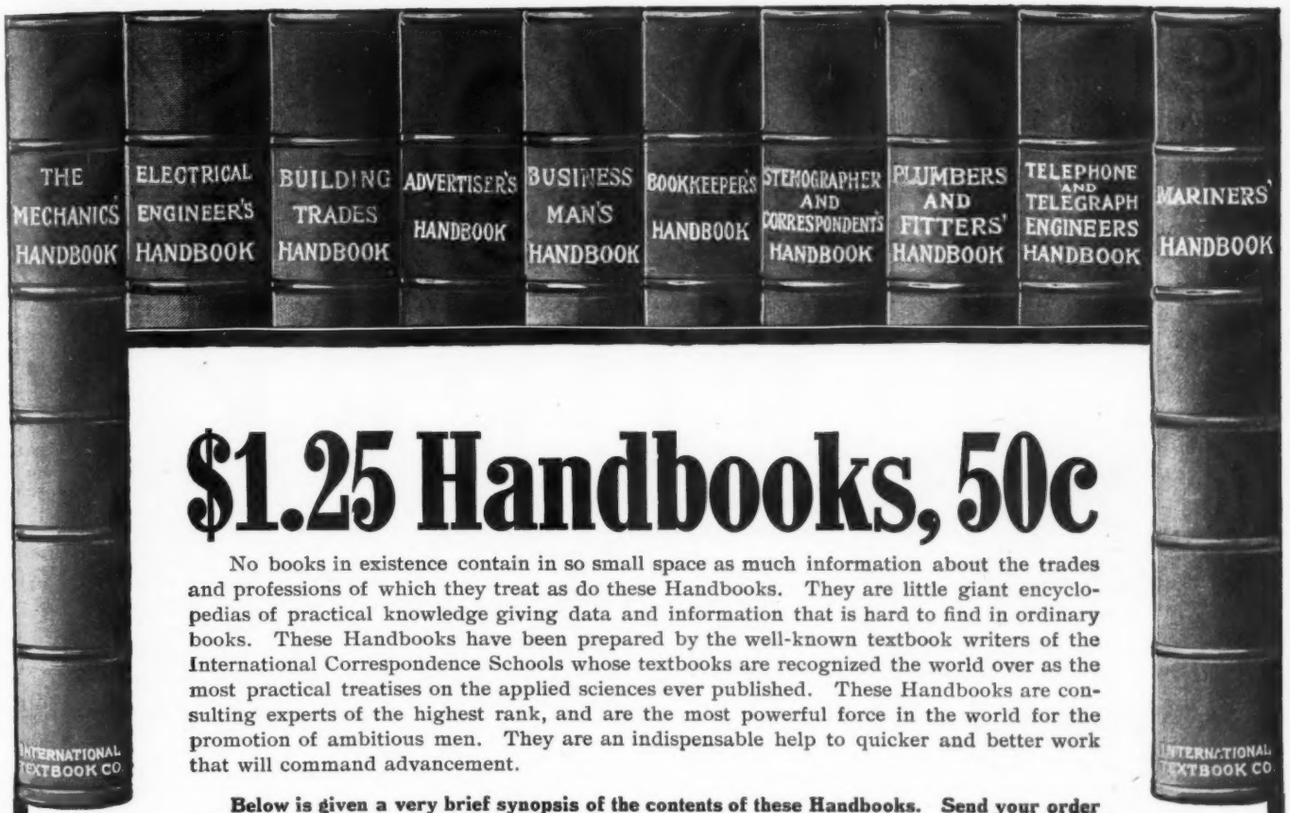
Water Columns
American Steam Gauge and Valve Mfg. Co. ... 60 and 61
Elliott Co. ... 7
Huyette Co., P. B. ... 88
Lunkenheimer Co. ... 4
National Tube Co. ... 89
Reliance Gauge Column Co. ... 79
Robertson & Sons, Jas. L. ... 69
Wright Mfg. Co. ... 78

Water Softening Apparatus
Dearborn Drug and Chemical Works ... 5
Harrison Safety Boiler Co. ... 63
National Tube Co. ... 89
Scaife & Sons Co., Wm. B. ... 104

Whistles
American Steam Gauge and Valve Mfg. Co. ... 60 and 61
Lunkenheimer Co. ... 4
Star Brass Mfg. Co. ... 111

Wrenches, Nut and Bolt
Trimont Mfg. Co. ... 100
Williams & Co., J. H. ... 74

Wrenches, Pipe
Trimont Mfg. Co. ... 100
Williams & Co., J. H. ... 74



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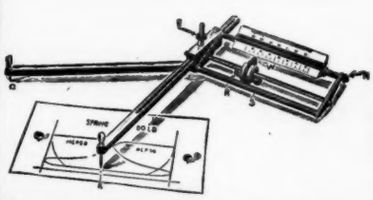

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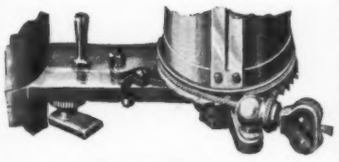

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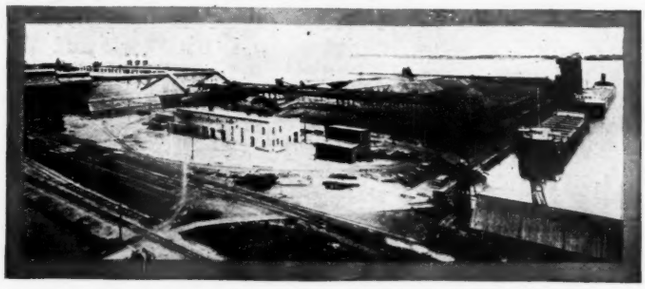

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